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Uno et al.

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(45) **Date of Patent: Feb. 21, 2012**

(54) **IMAGE FORMING APPARATUS AND DEVELOPER SUPPLY METHOD THEREFOR**

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(73) Assignee: **Ricoh Company, Limited**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 578 days.

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(30) **Foreign Application Priority Data**

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G03G 15/06 (2006.01)
G03G 15/14 (2006.01)
G03G 21/00 (2006.01)

(52) **U.S. Cl.** **399/27**; 399/61; 399/256; 399/258

(58) **Field of Classification Search** 399/27, 399/29, 30, 58, 59, 60, 61, 62, 63, 224, 255, 399/256, 258, 263, 298, 299, 300, 302, 308
See application file for complete search history.

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Assistant Examiner — Fred L Braun
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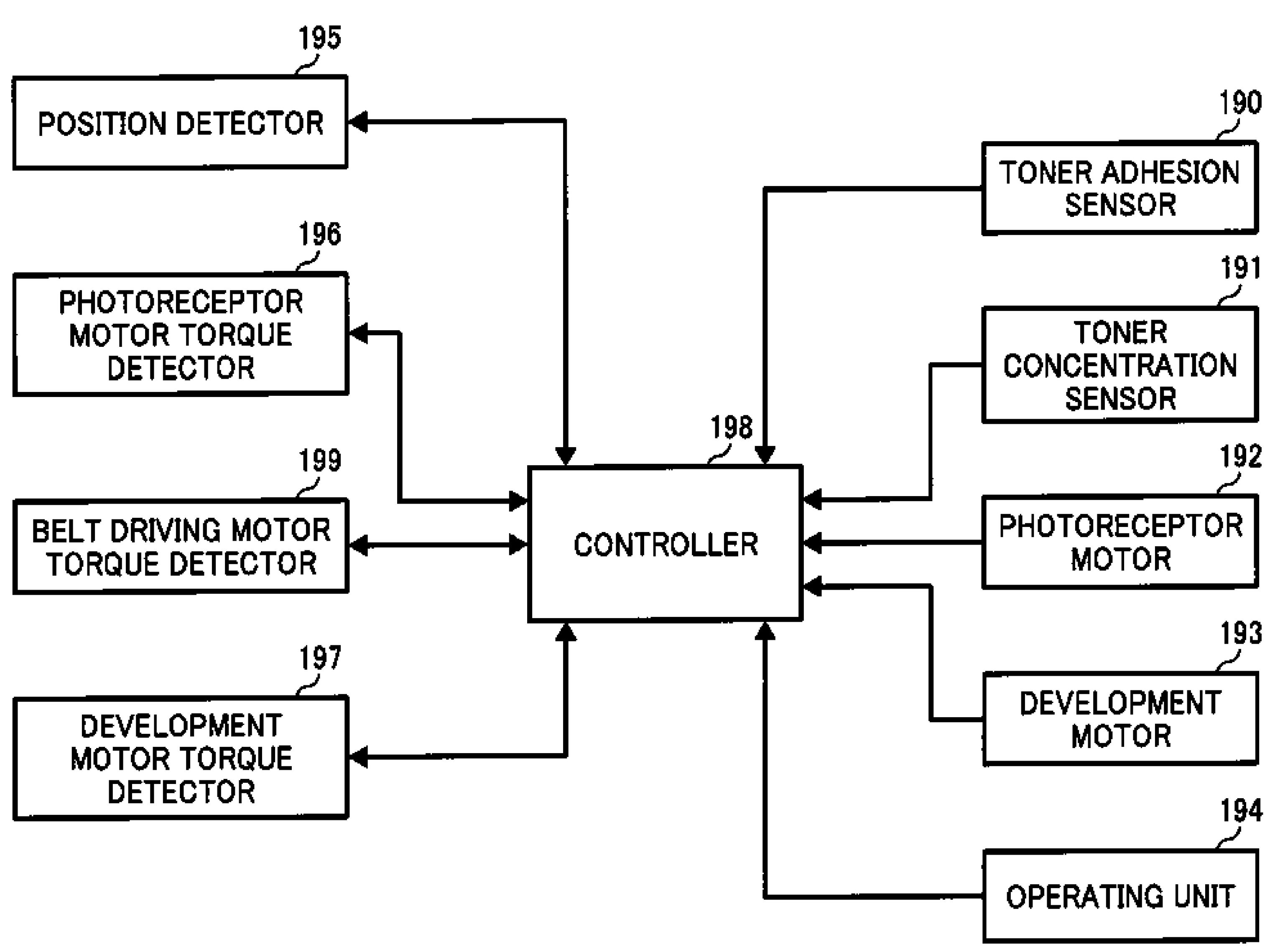
(57) **ABSTRACT**

An image forming method and apparatus, the apparatus including a latent image carrier configured to carry a latent image thereon, a developing unit disposed facing the latent image carrier to develop the latent image with developer, a developer container containing the developer and attachable to the image forming apparatus, a developer detector configured to detect the presence of the developer in the developing unit, and a developer supply controller, and a disengagement detector configured to detect whether or not an intermediate transfer member is disengaged from the latent image carrier. The developer supply controller prohibits supply of the developer from the developer container to the developing unit when the developer detector detects that the developer is present in the developing unit, and when the disengagement detector detects that the intermediate transfer member is not disengaged from the latent image carrier.

16 Claims, 24 Drawing Sheets



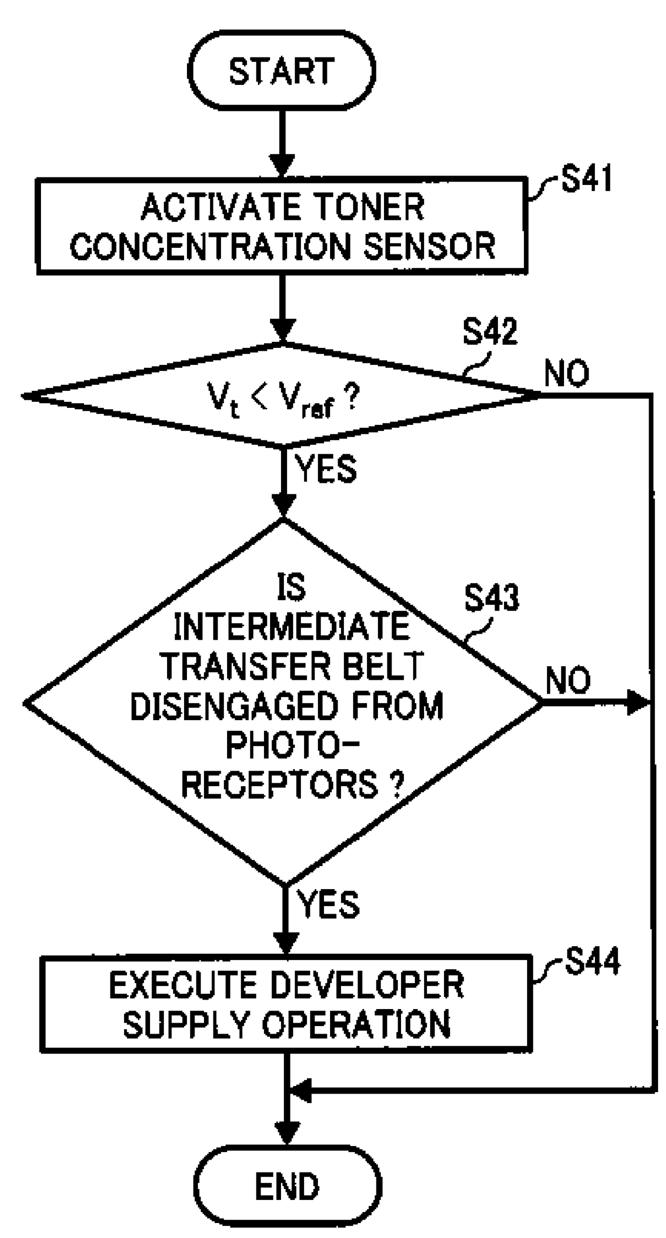


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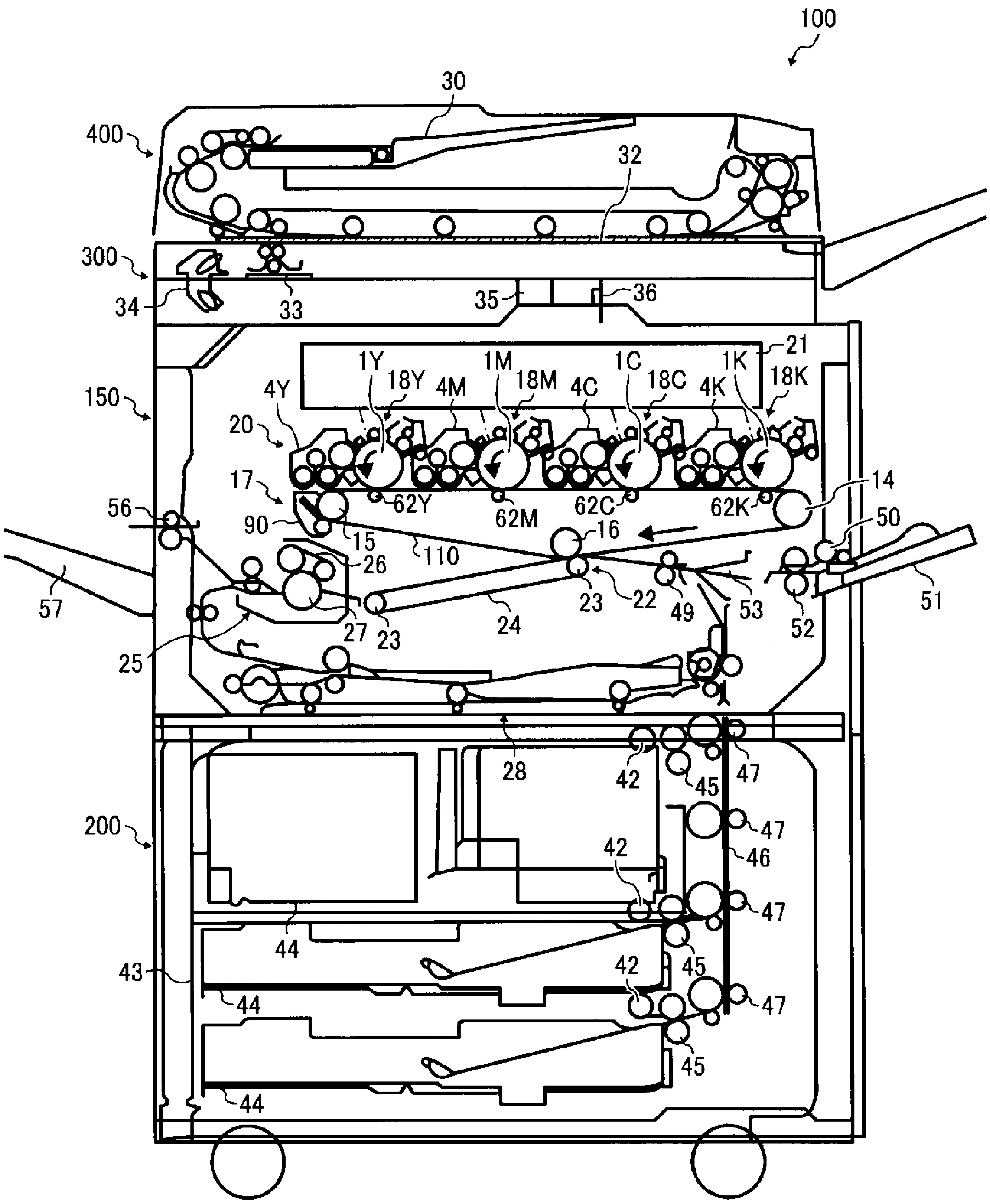
FIG. 1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30
400
32
300
34
33
35
36
21
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18Y
4M
1M
18M
4C
1C
18C
4K
1K
18K
150
4Y
20
17
14
56
62Y
62M
62C
62K
50
90
15
16
110
26
23
22
49
53
52
51
57
27
23
24
25
28
42
45
47
200
47
46
42
47
44
45
43
42
47
44
45
44

FIG. 2

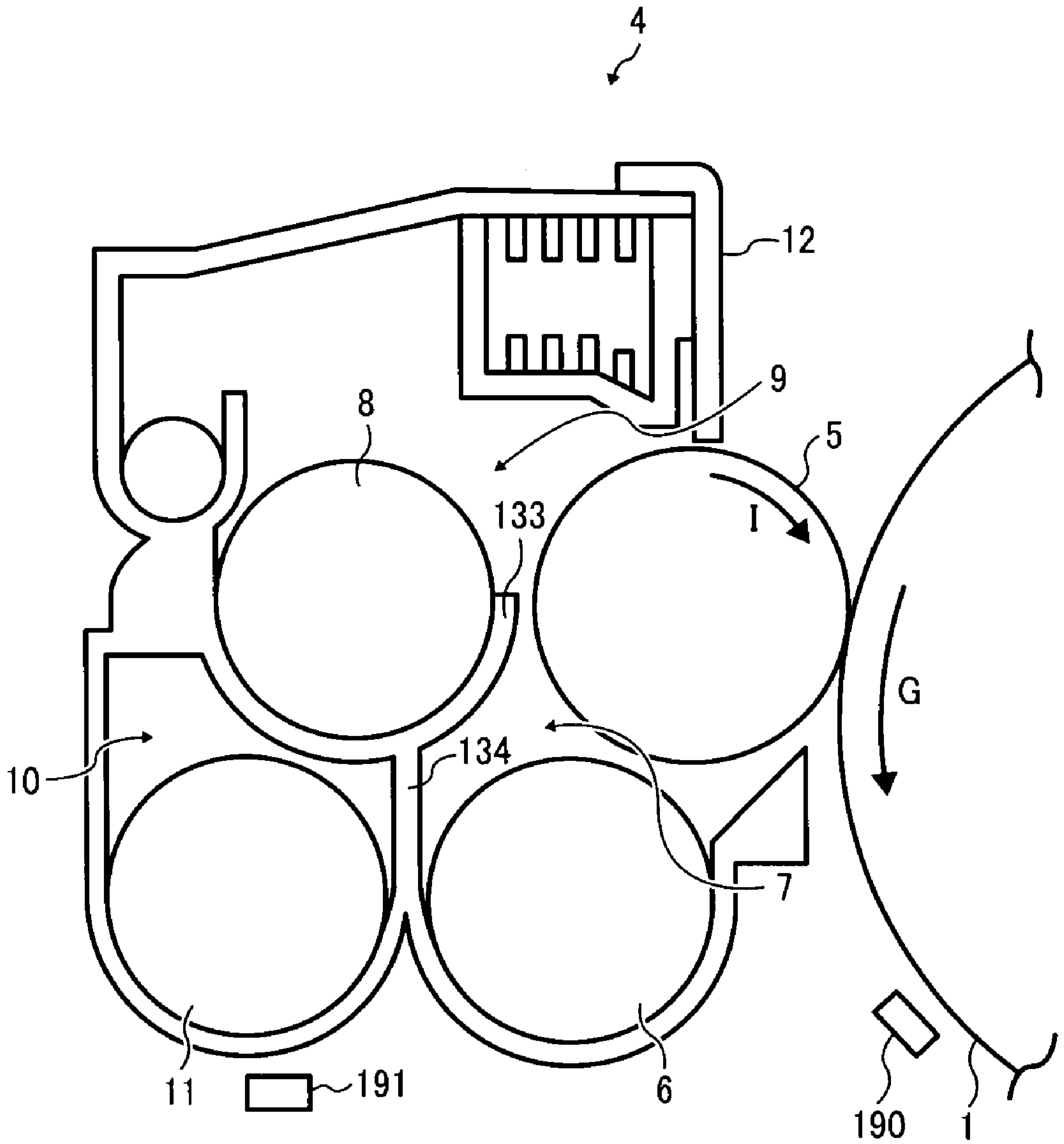


FIG. 3

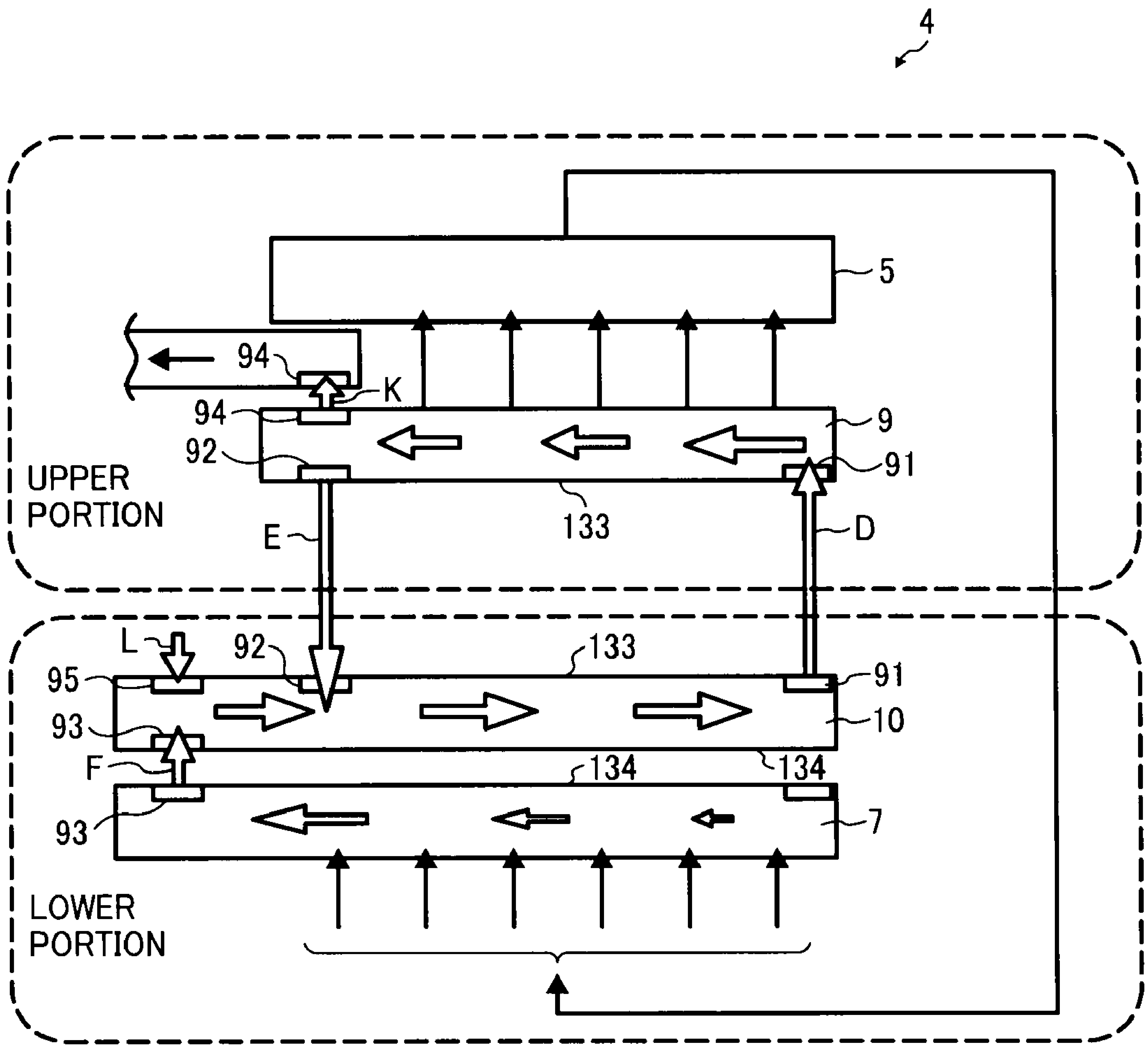

4
5
94
K
94
9
92
91
UPPER PORTION
133
E
D
L
92
133
95
91
93
10
F
134
134
93
7
LOWER PORTION

FIG. 4

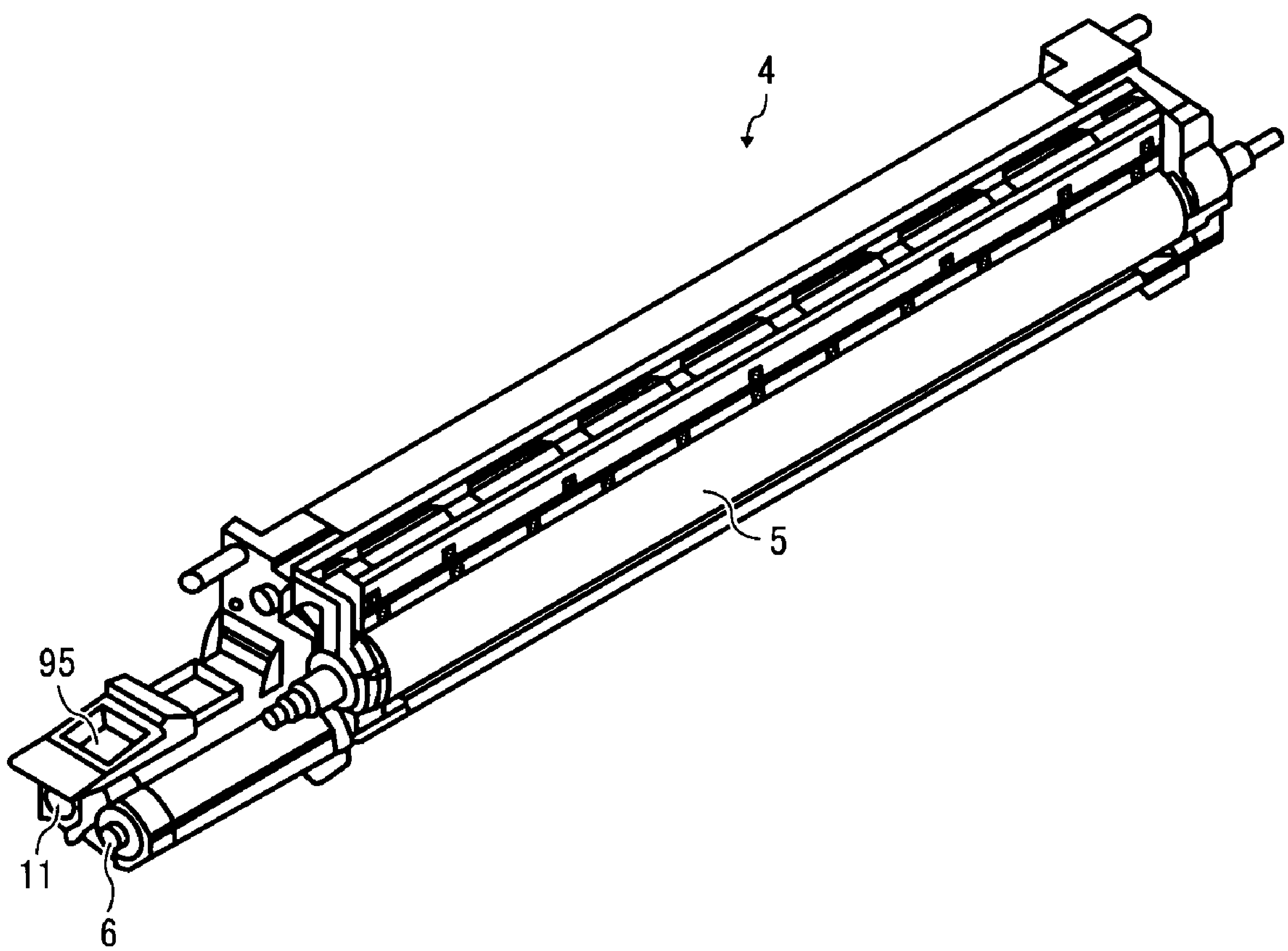


FIG. 5

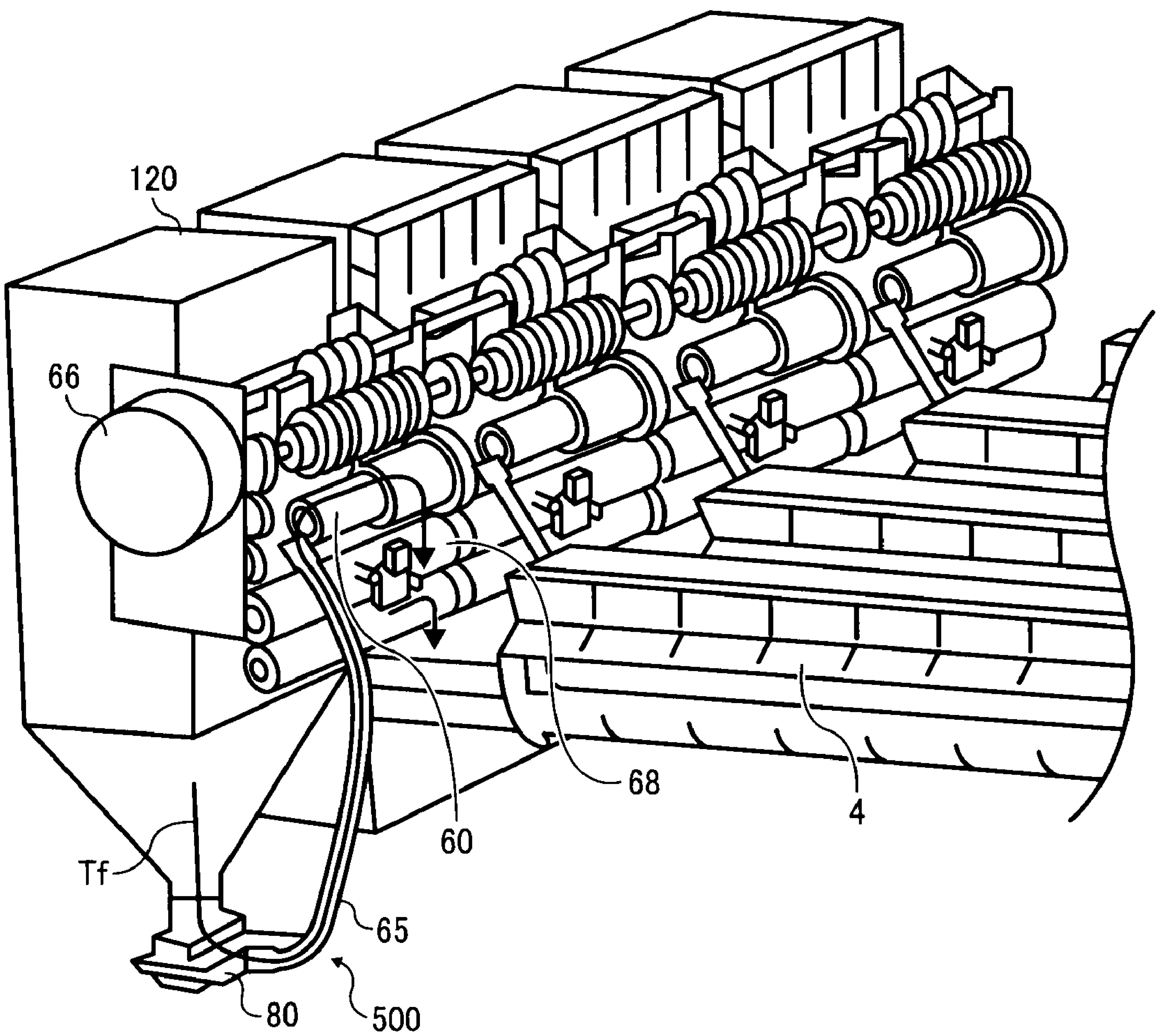


FIG. 6

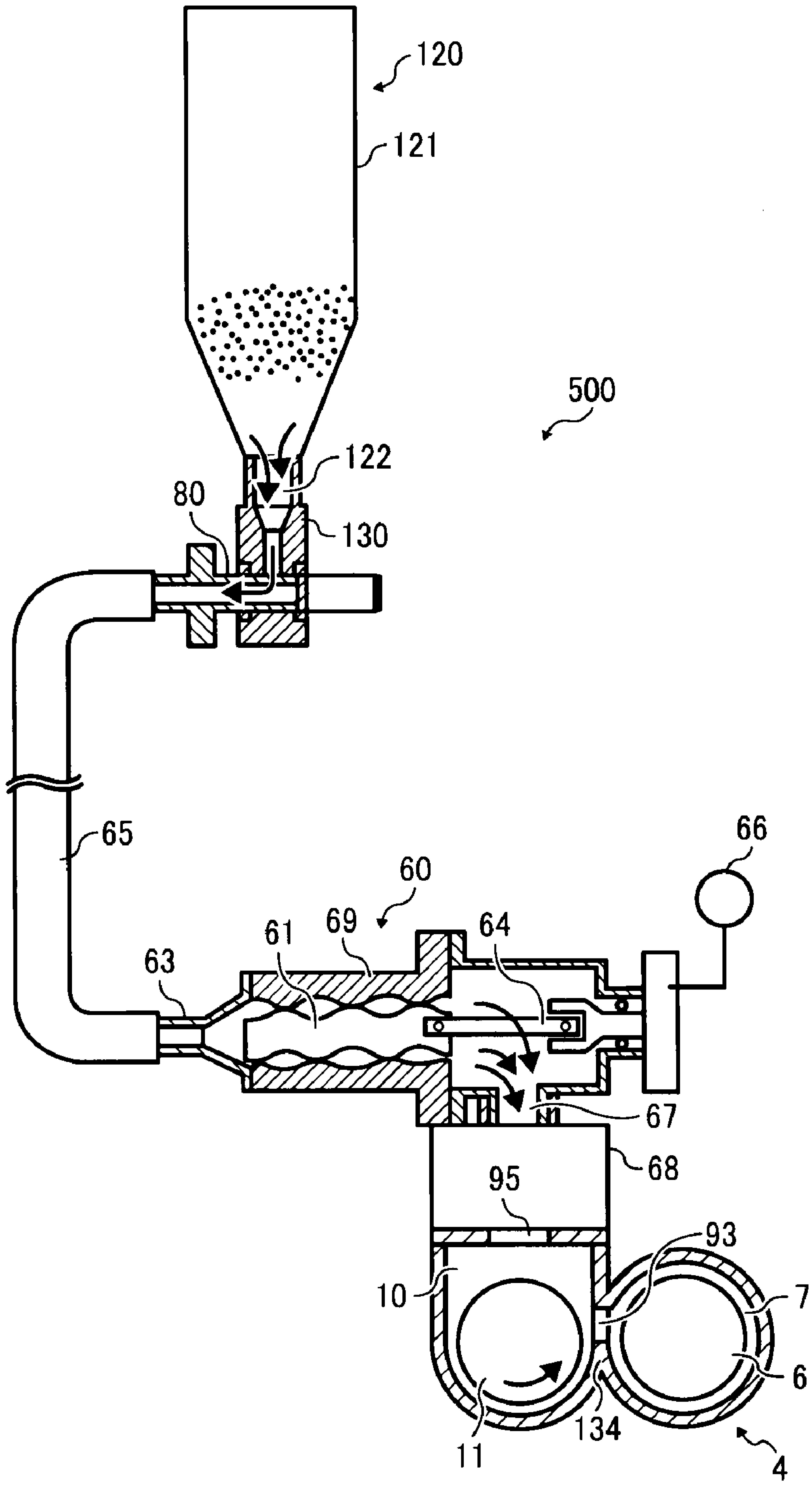


FIG. 7

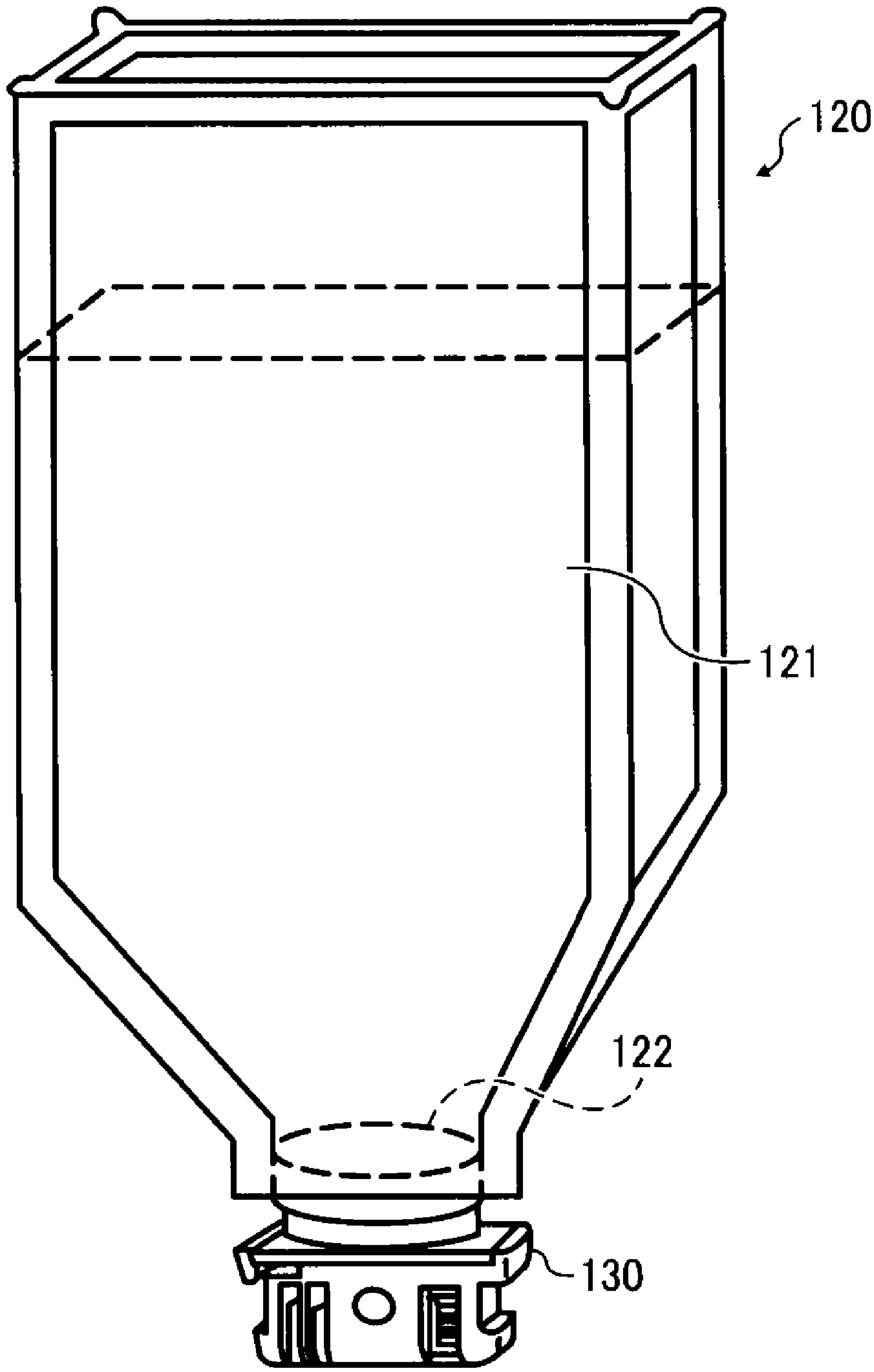


FIG. 8

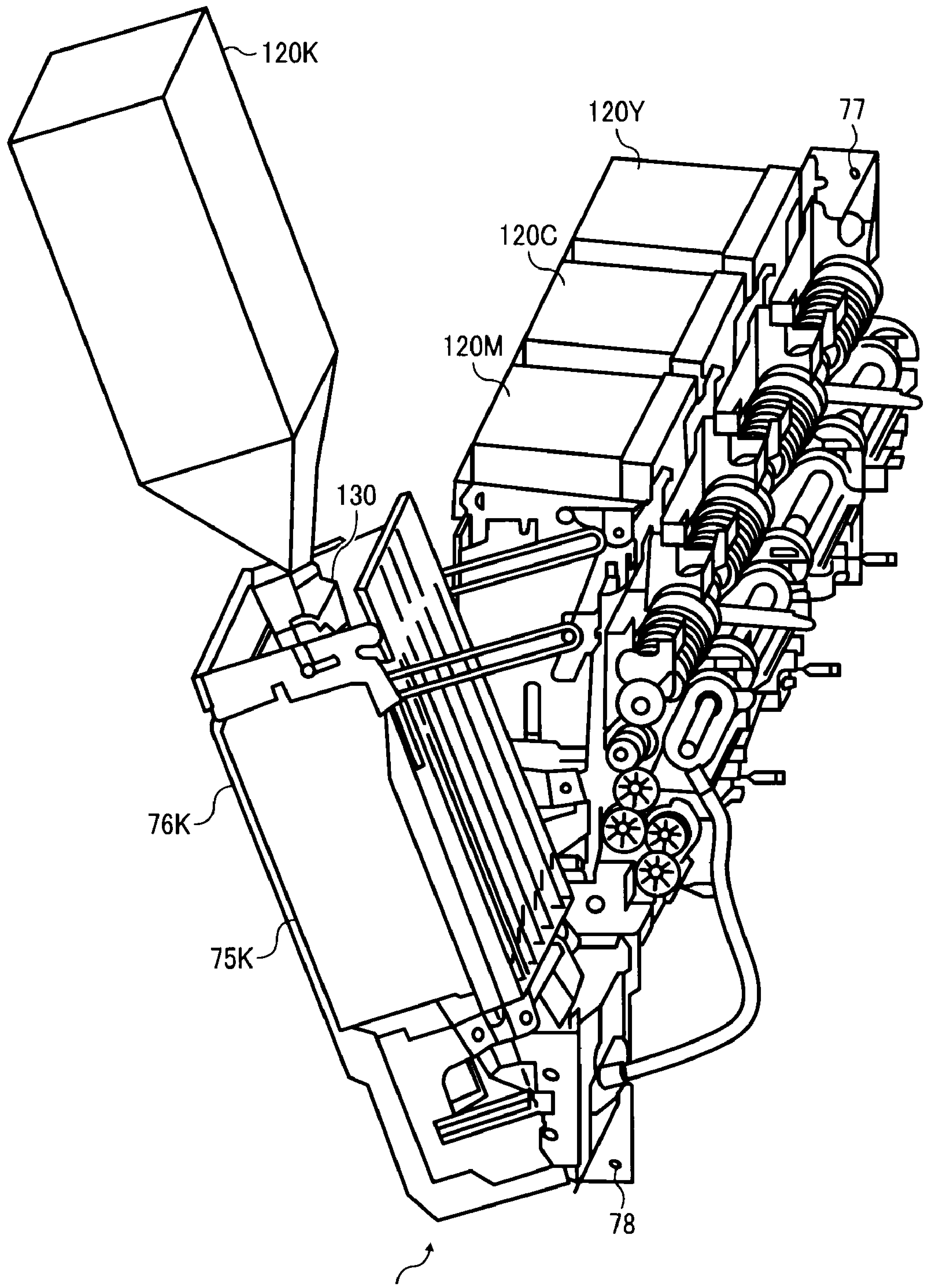
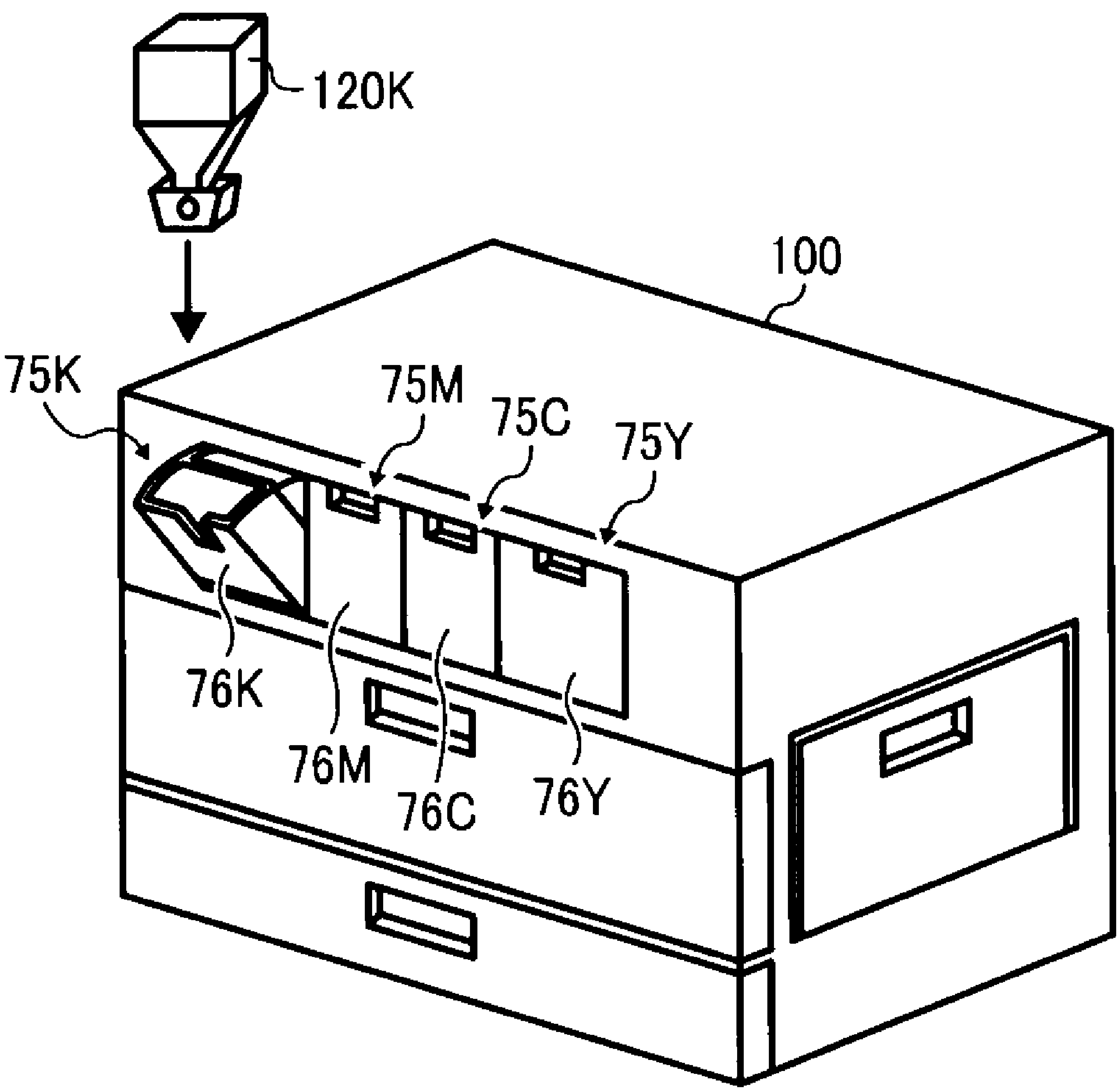


FIG. 9



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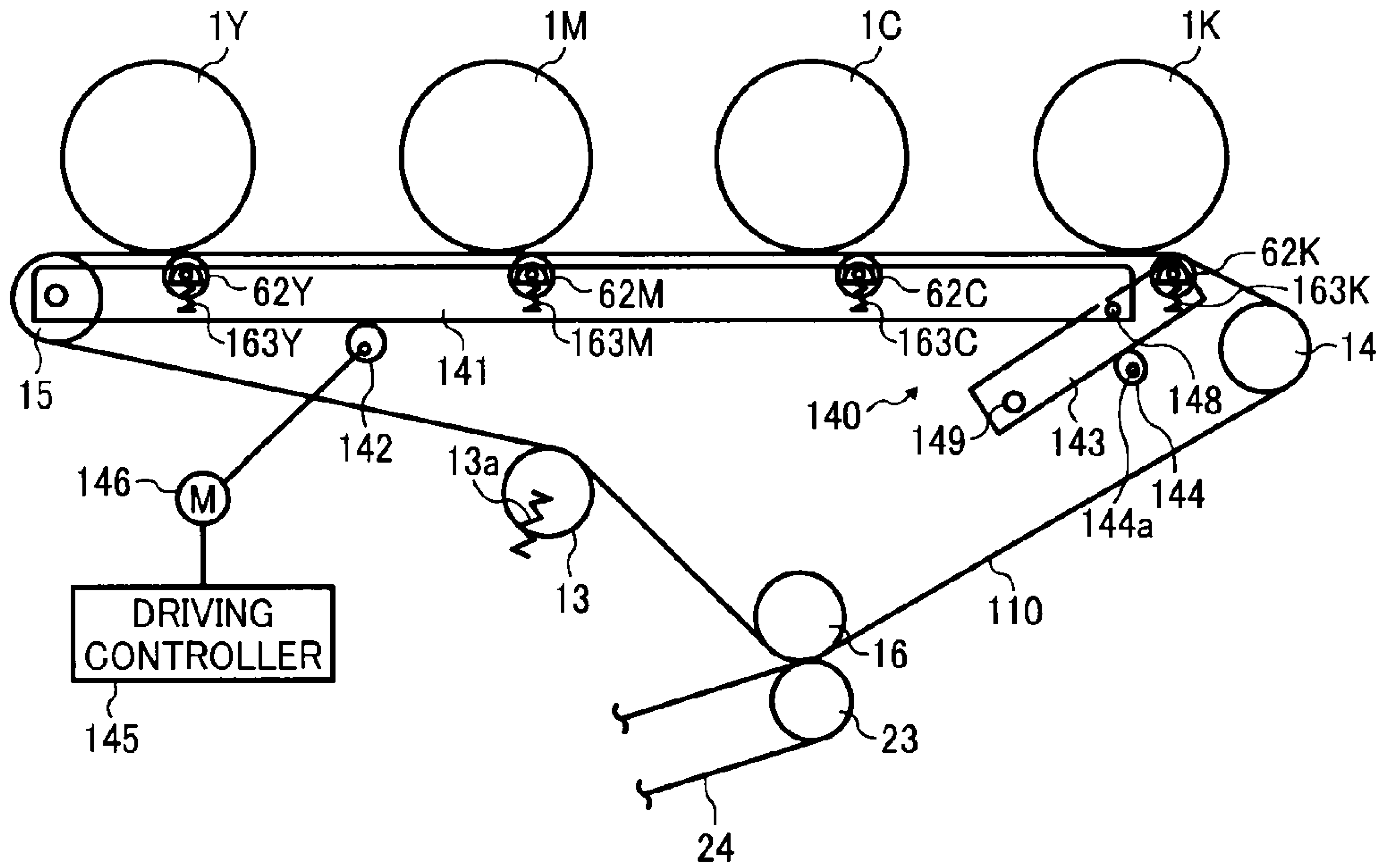
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1M
1C
1K
62Y
62M
62C
62K
163K
163Y
163M
163C
14
15
141
142
140
149
143
148
144
144a
146
M
13a
13
DRIVING CONTROLLER
145
16
110
23
24

FIG. 11

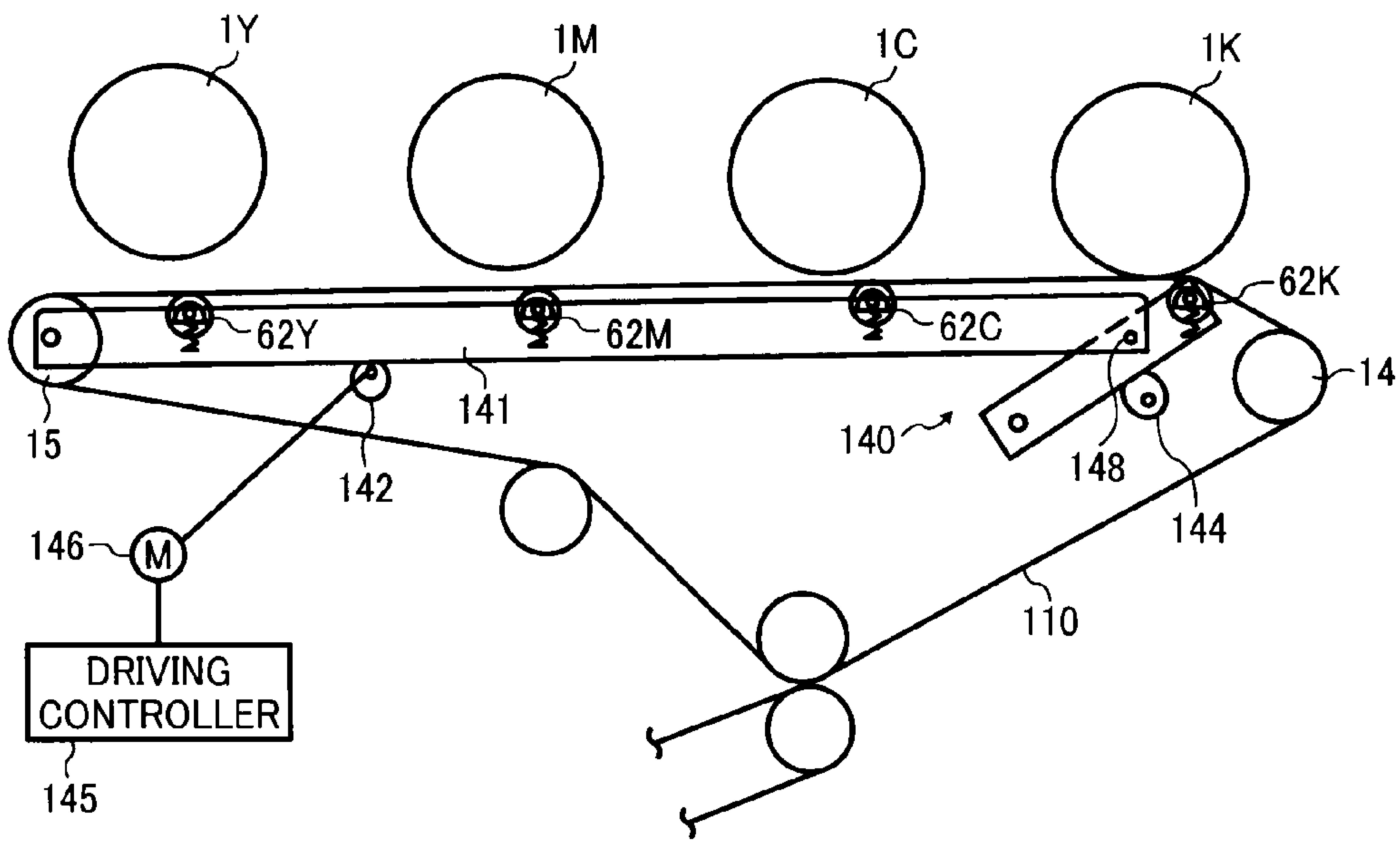

1Y
1M
1C
1K
62Y
62M
62C
62K
14
15
141
142
140
148
144
146
M
110
DRIVING CONTROLLER
145

FIG. 12

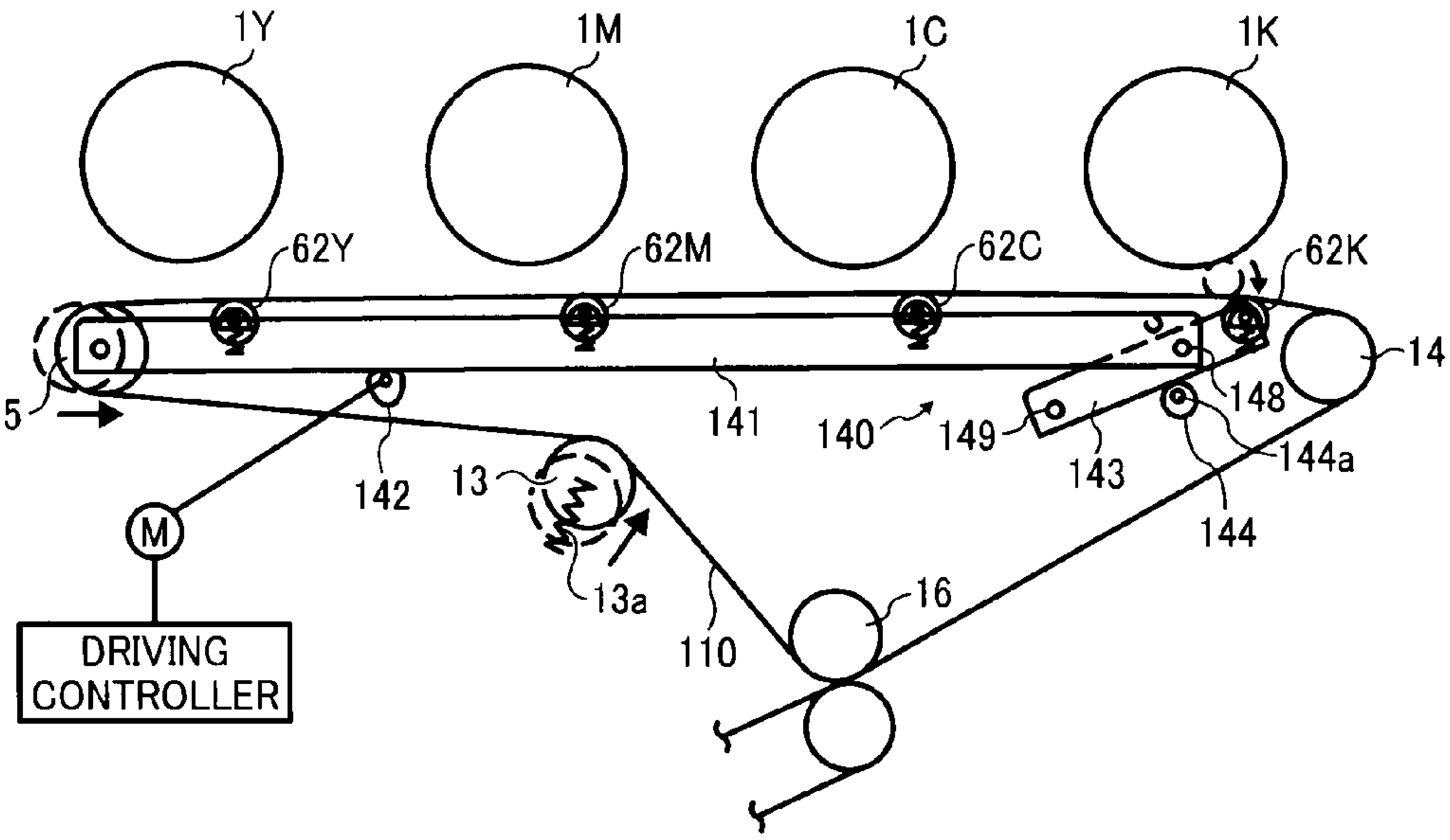

1Y
1M
1C
1K
62Y
62M
62C
62K
15
141
140
149
148
143
144a
144
14
142
13
13a
110
16
M
DRIVING
CONTROLLER

FIG. 13

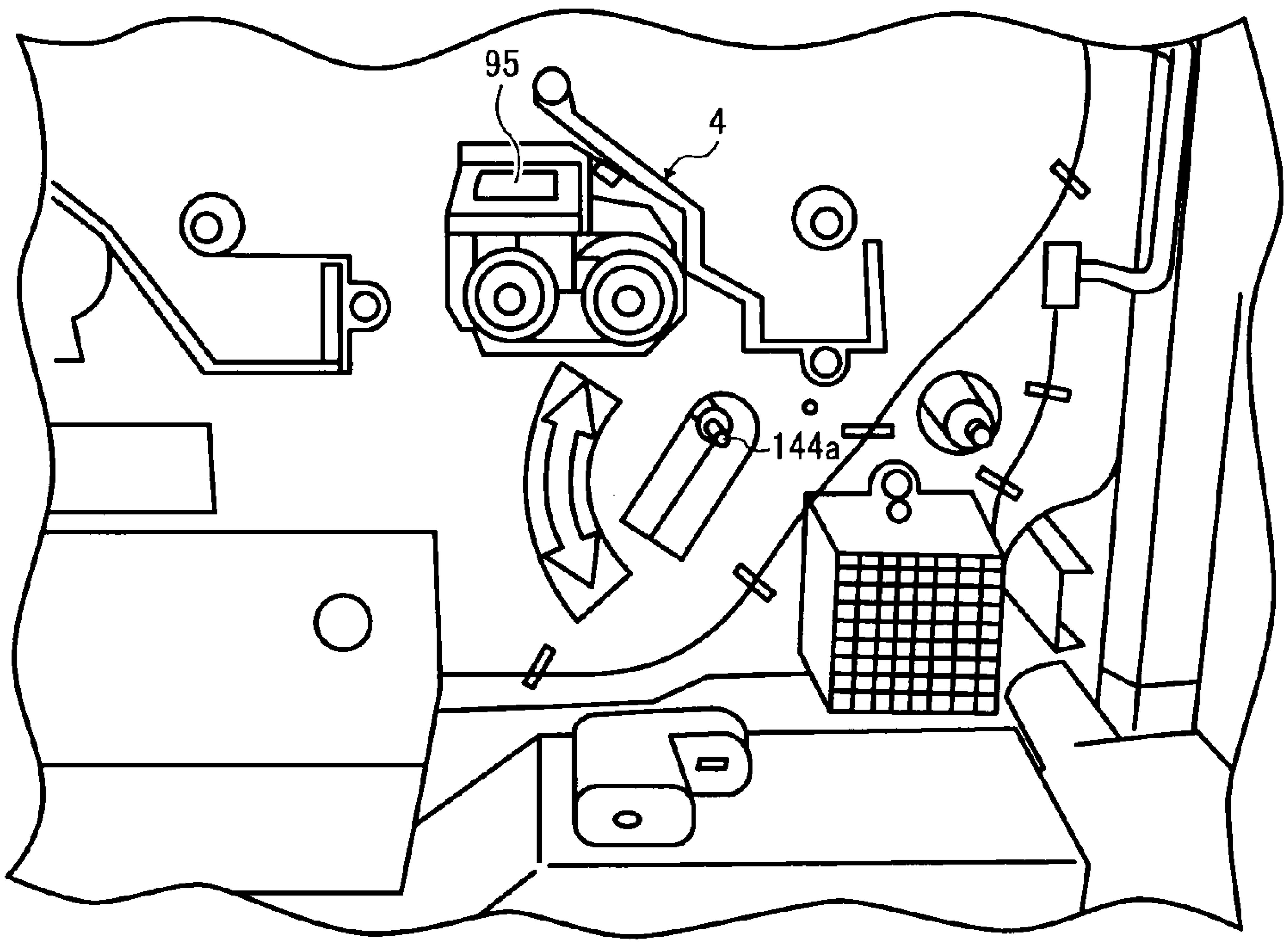

95
4
144a

FIG. 14

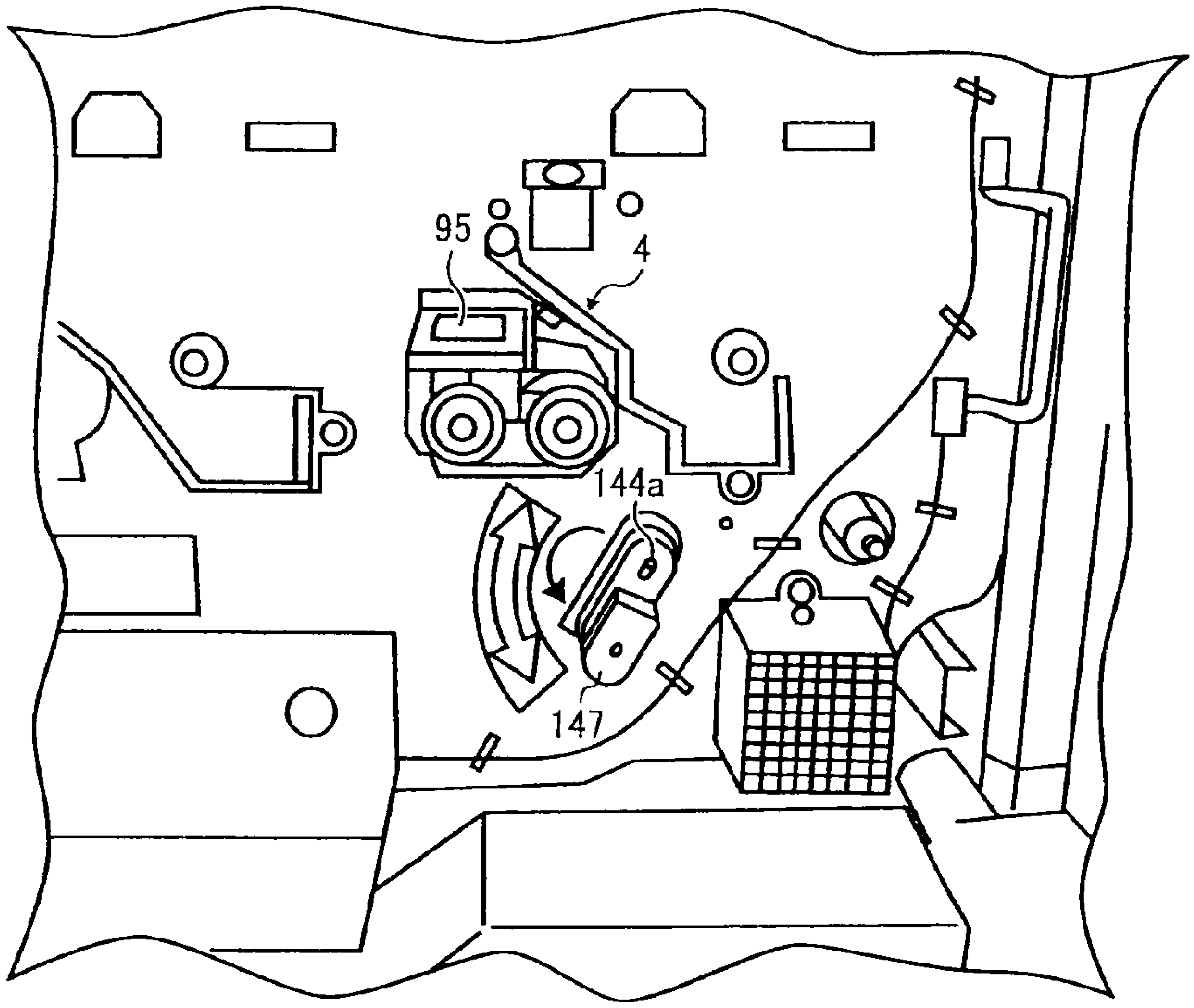


FIG. 15

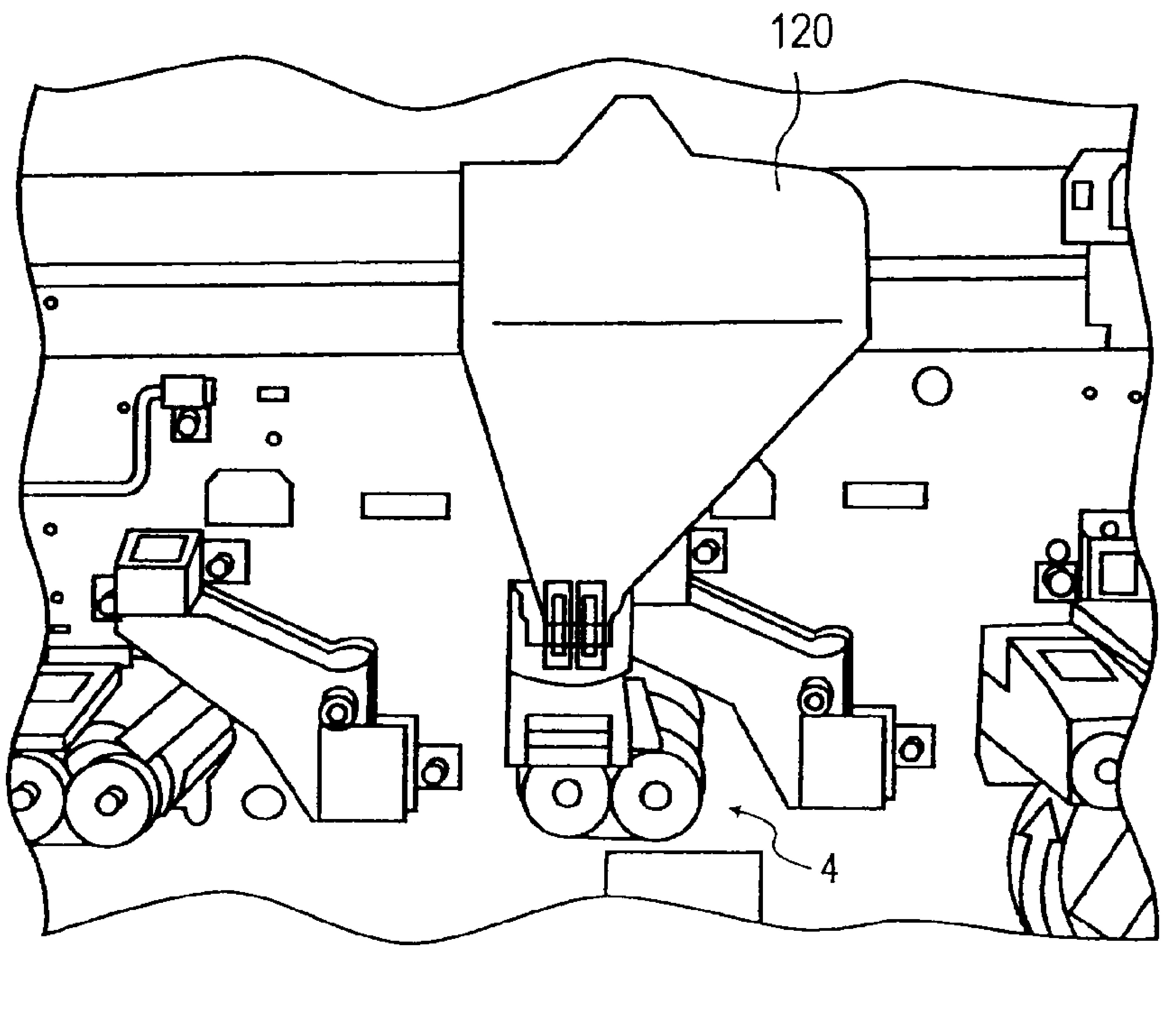


FIG. 16

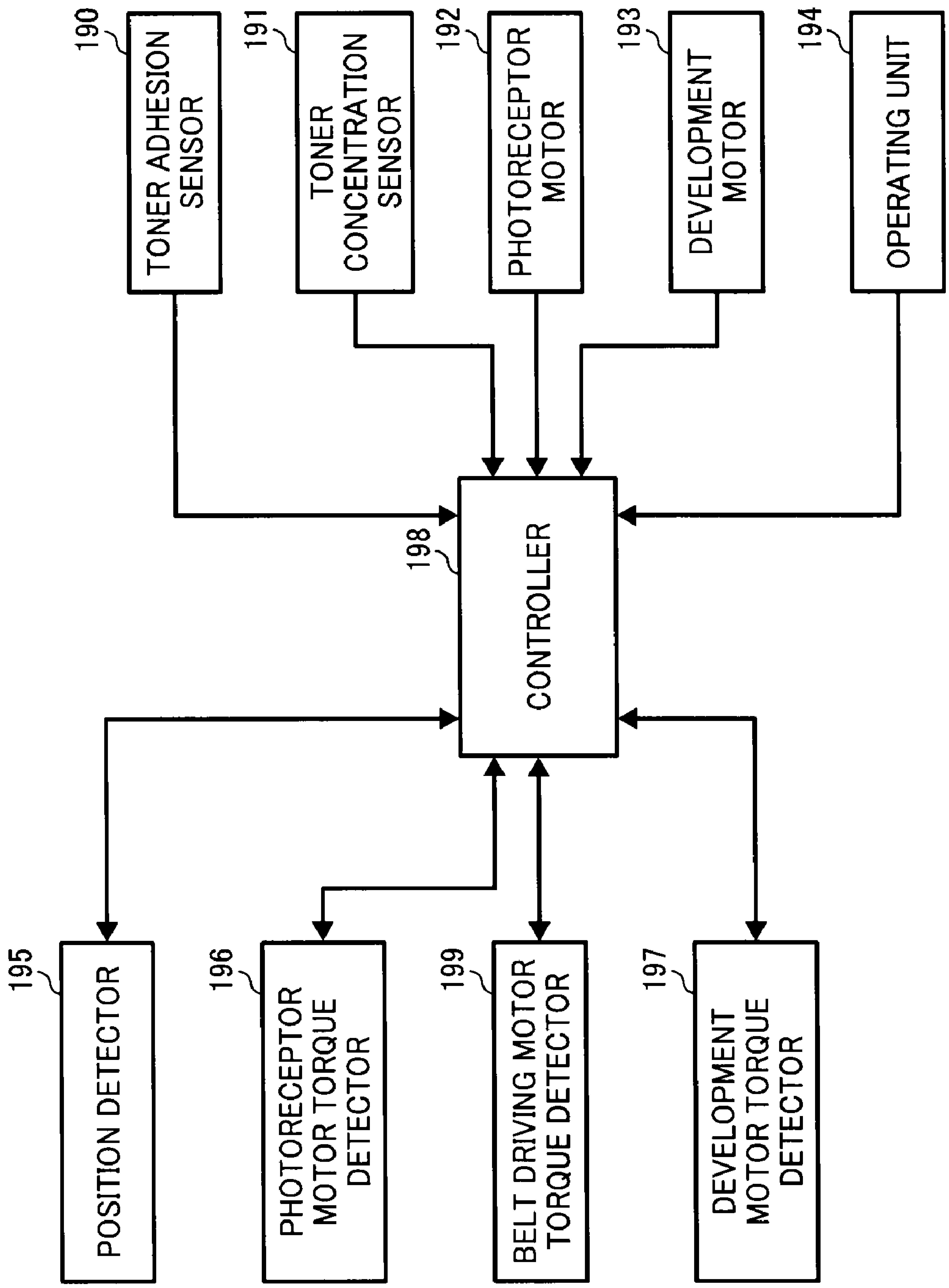

190
TONER ADHESION SENSOR
191
TONER CONCENTRATION SENSOR
192
PHOTORECEPTOR MOTOR
193
DEVELOPMENT MOTOR
194
OPERATING UNIT
198
CONTROLLER
195
POSITION DETECTOR
196
PHOTORECEPTOR MOTOR TORQUE DETECTOR
199
BELT DRIVING MOTOR TORQUE DETECTOR
197
DEVELOPMENT MOTOR TORQUE DETECTOR

FIG. 17

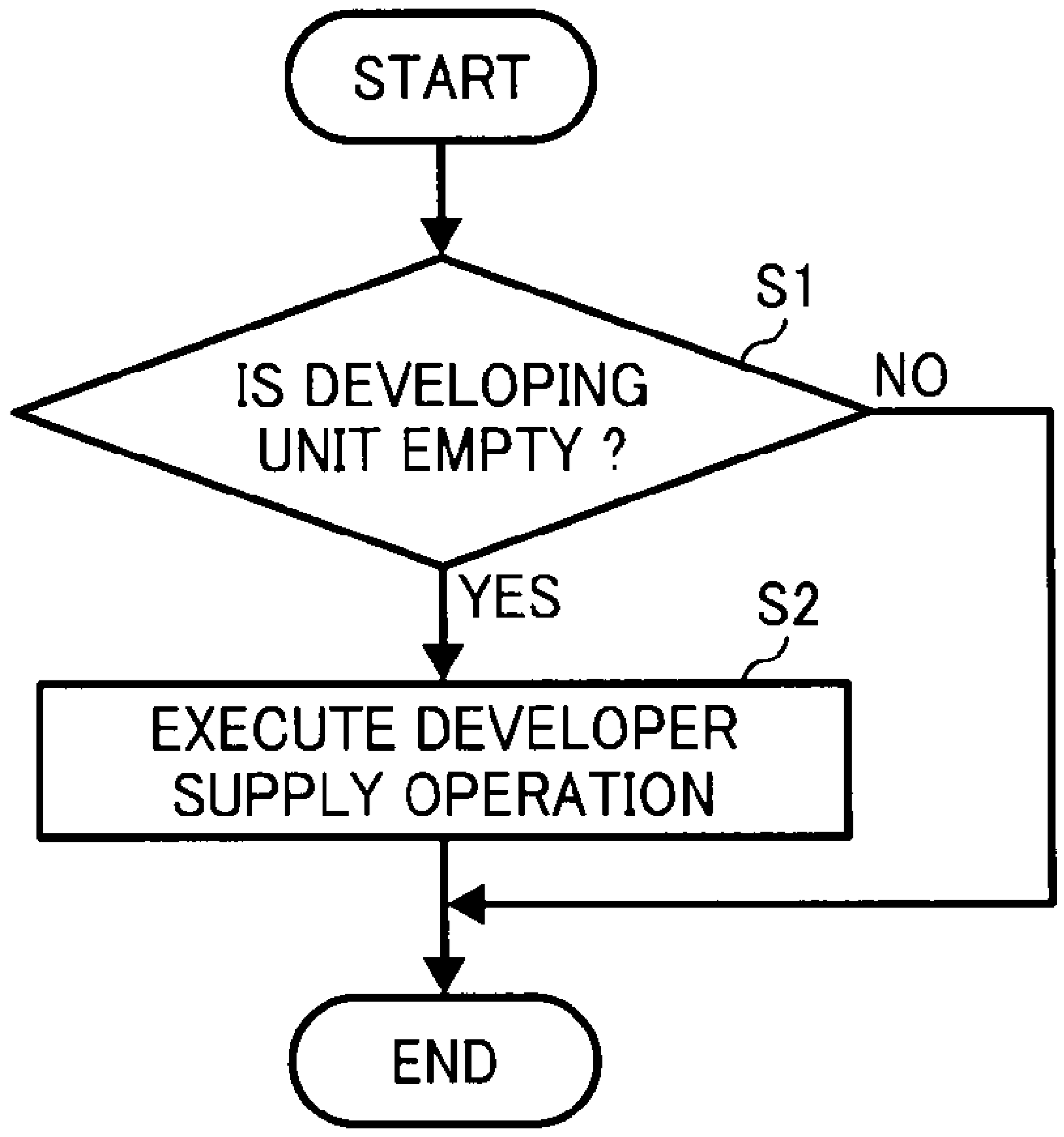

START
S1
IS DEVELOPING UNIT EMPTY ?
NO
YES
S2
EXECUTE DEVELOPER SUPPLY OPERATION
END

FIG. 18

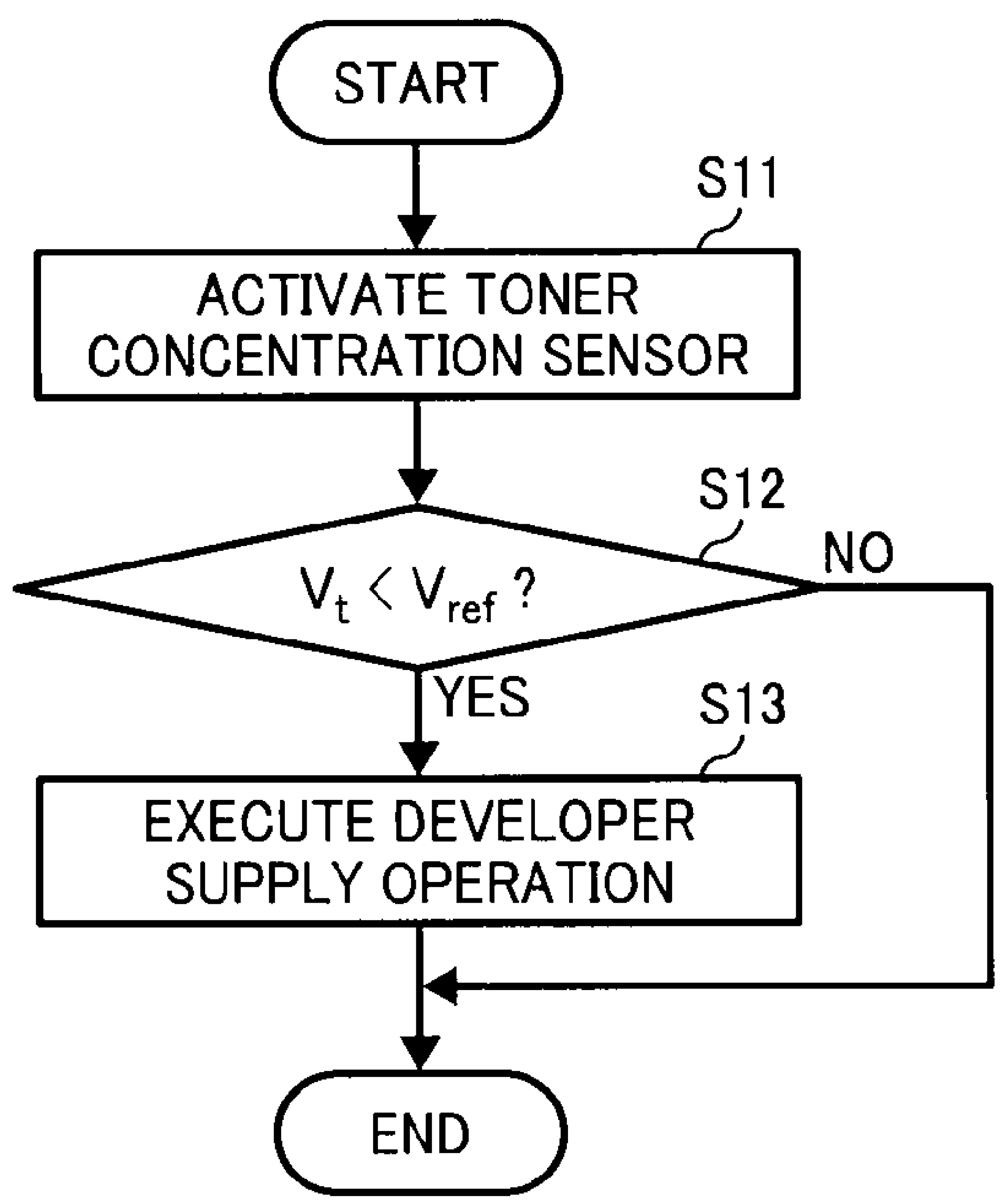
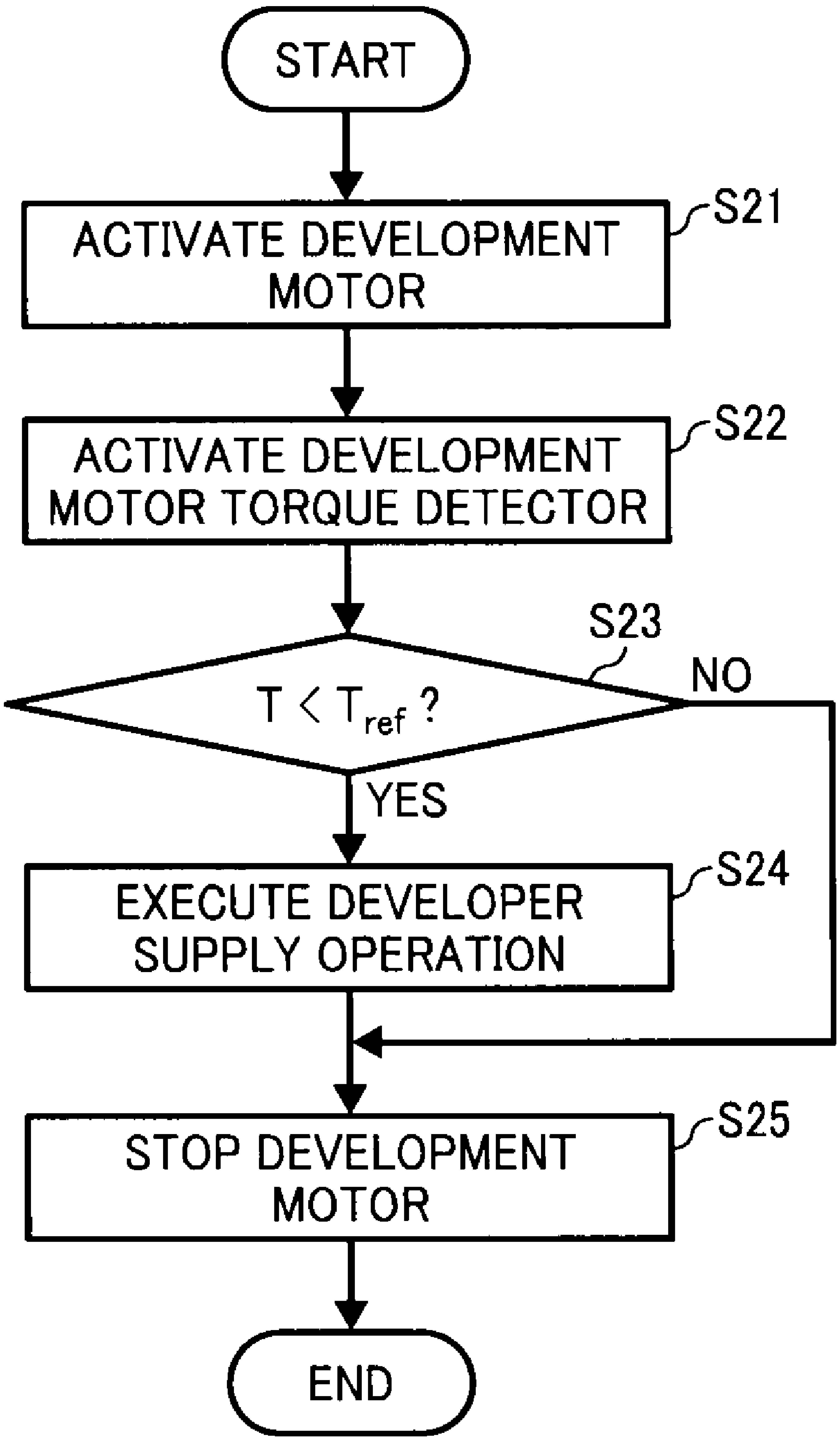

START
S11
ACTIVATE TONER CONCENTRATION SENSOR
S12
$V_t < V_{ref}$?
NO
YES
S13
EXECUTE DEVELOPER SUPPLY OPERATION
END

FIG. 19



START
ACTIVATE DEVELOPMENT MOTOR
S21
ACTIVATE DEVELOPMENT MOTOR TORQUE DETECTOR
S22
S23
T < Tref ?
NO
YES
EXECUTE DEVELOPER SUPPLY OPERATION
S24
STOP DEVELOPMENT MOTOR
S25
END

FIG. 20

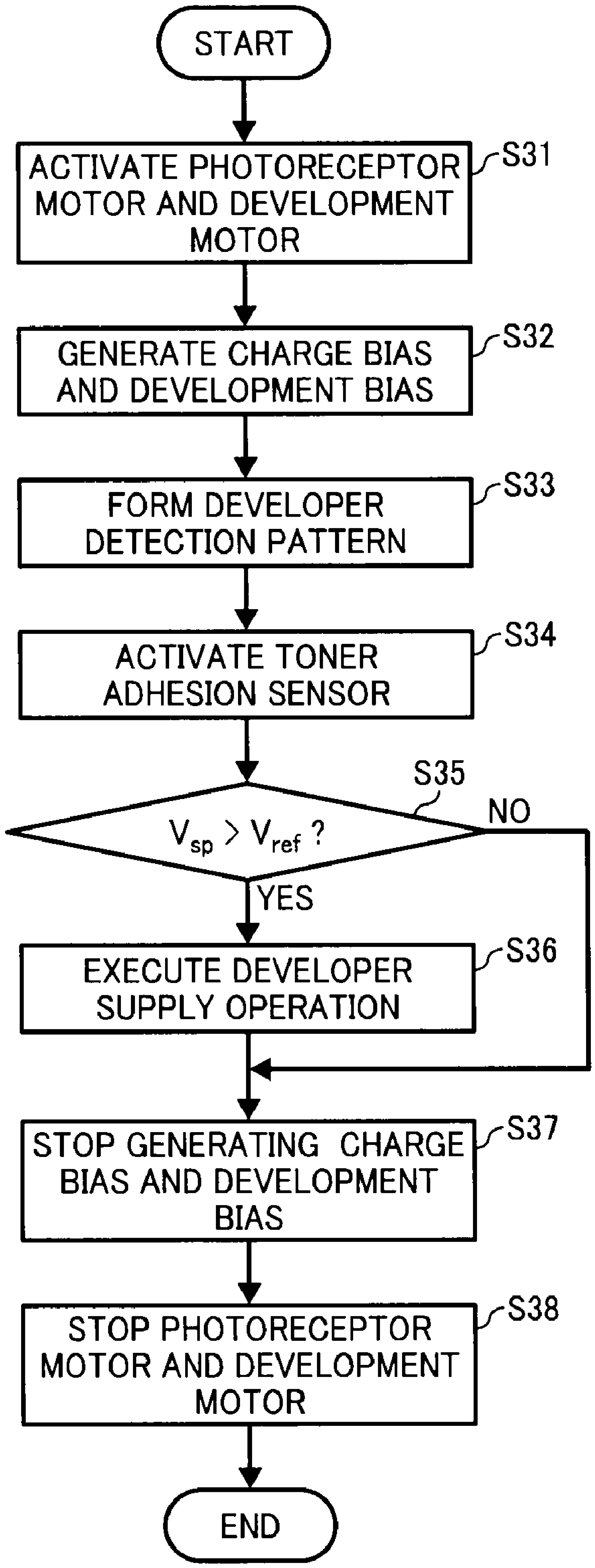

START
ACTIVATE PHOTORECEPTOR MOTOR AND DEVELOPMENT MOTOR
S31
GENERATE CHARGE BIAS AND DEVELOPMENT BIAS
S32
FORM DEVELOPER DETECTION PATTERN
S33
ACTIVATE TONER ADHESION SENSOR
S34
S35
$V_{sp} > V_{ref}$?
NO
YES
EXECUTE DEVELOPER SUPPLY OPERATION
S36
STOP GENERATING CHARGE BIAS AND DEVELOPMENT BIAS
S37
STOP PHOTORECEPTOR MOTOR AND DEVELOPMENT MOTOR
S38
END

FIG. 21

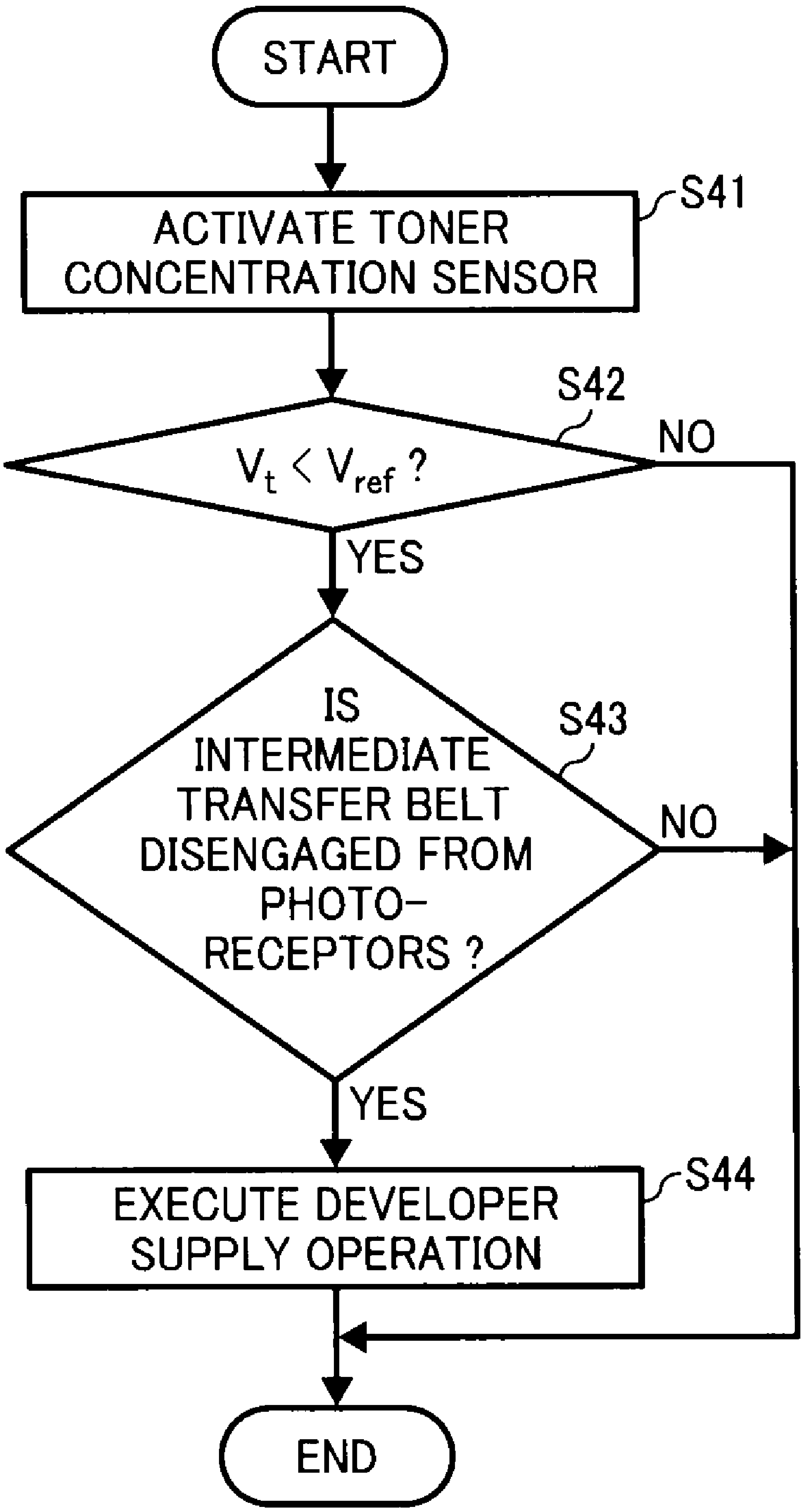

START
ACTIVATE TONER CONCENTRATION SENSOR
S41
S42
$V_t < V_{ref}$?
NO
YES
IS INTERMEDIATE TRANSFER BELT DISENGAGED FROM PHOTO-RECEPTORS ?
S43
NO
YES
EXECUTE DEVELOPER SUPPLY OPERATION
S44
END

FIG. 22A

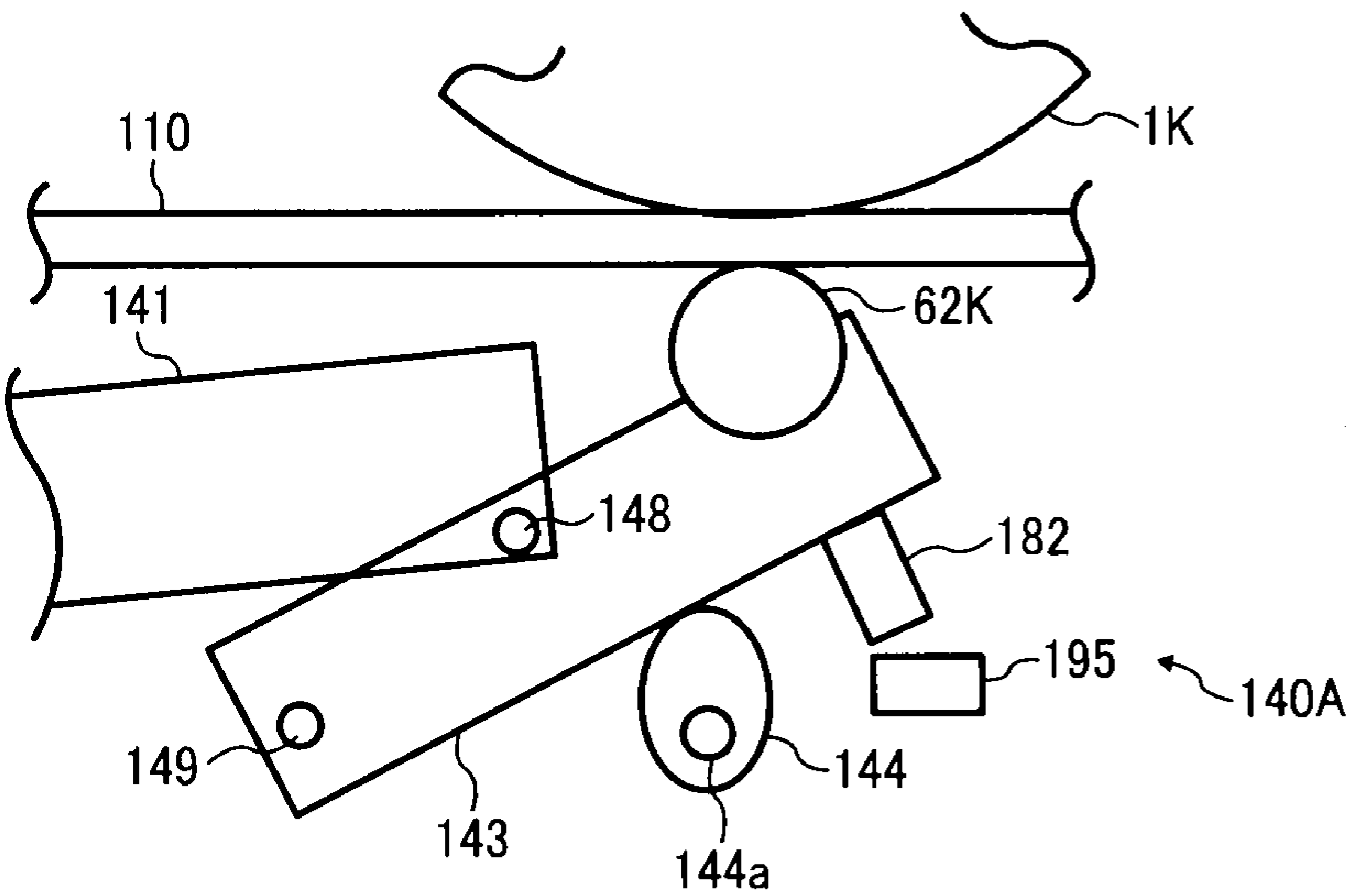


FIG. 22B

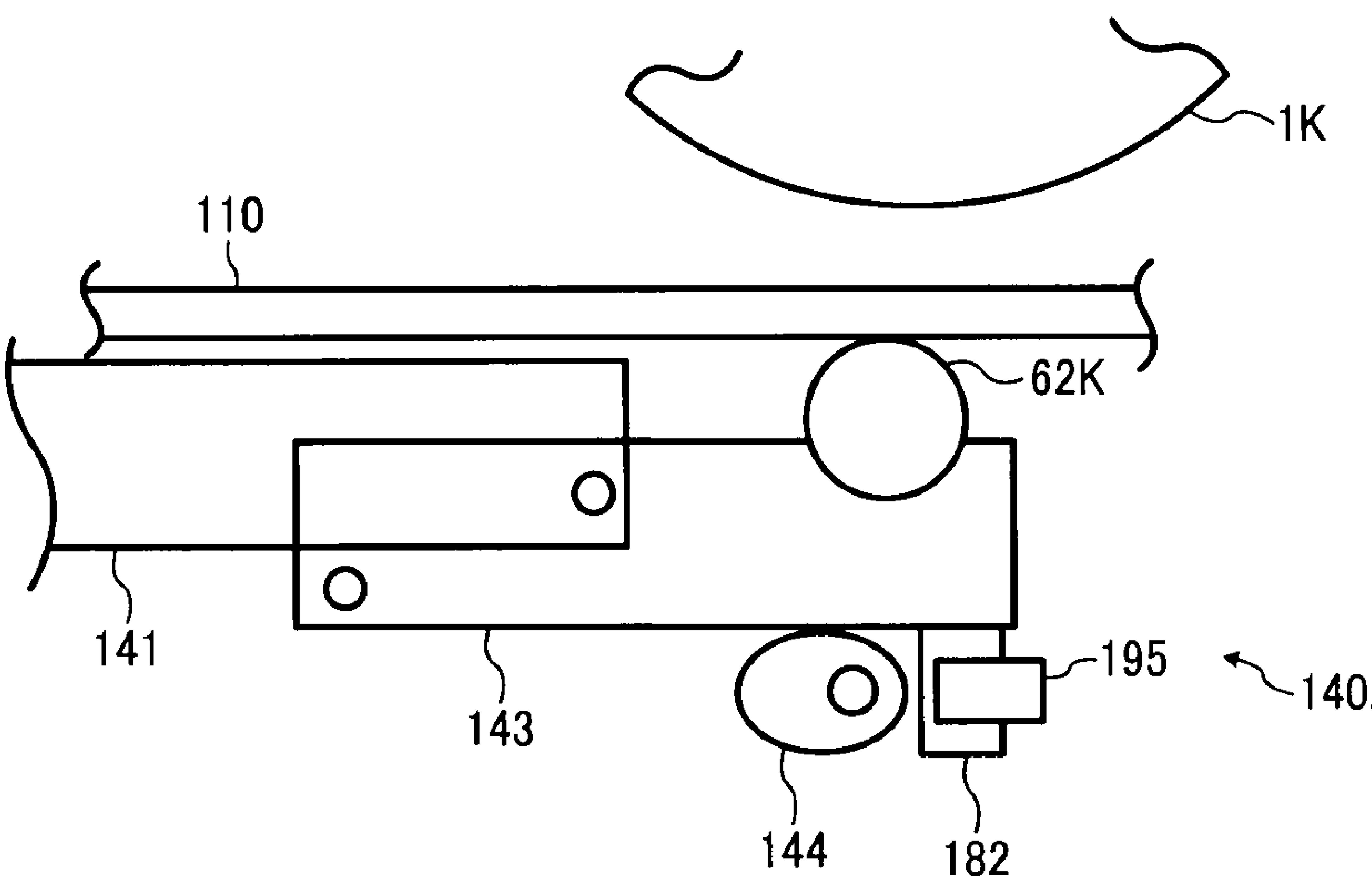


FIG. 23

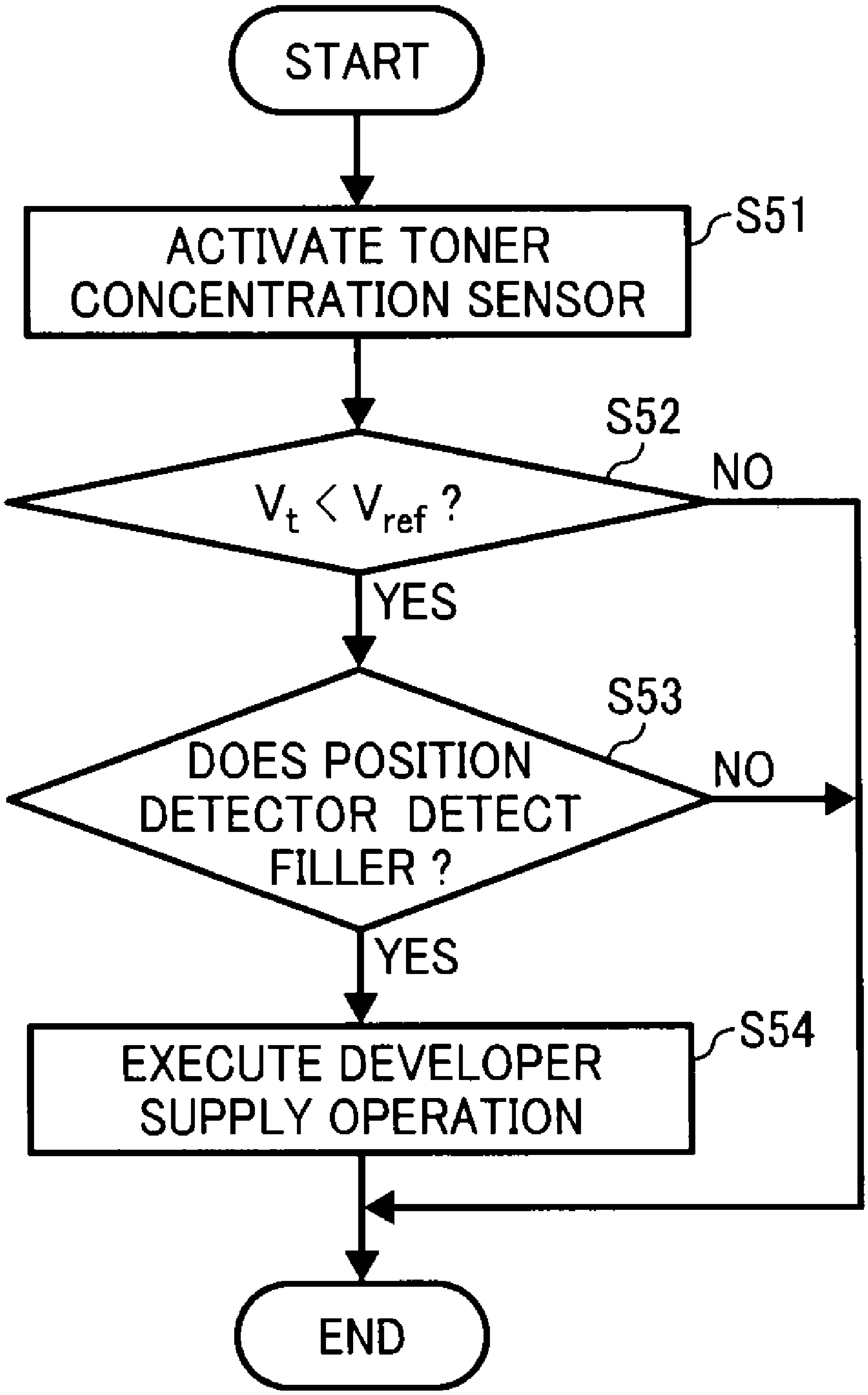

START
ACTIVATE TONER CONCENTRATION SENSOR
S51
$V_t < V_{ref}$?
S52
NO
YES
DOES POSITION DETECTOR DETECT FILLER ?
S53
NO
YES
EXECUTE DEVELOPER SUPPLY OPERATION
S54
END

FIG. 24A

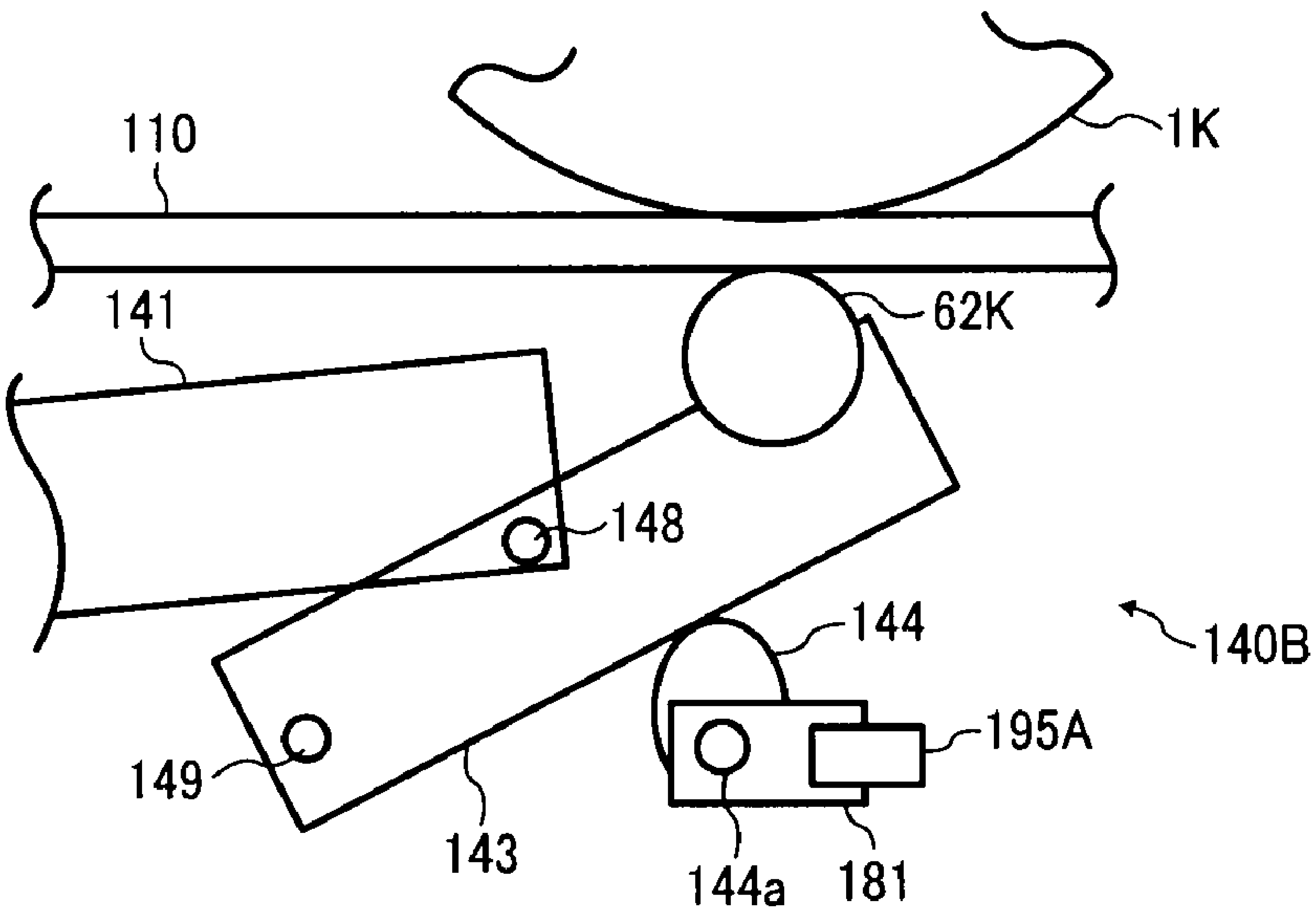


FIG. 24B

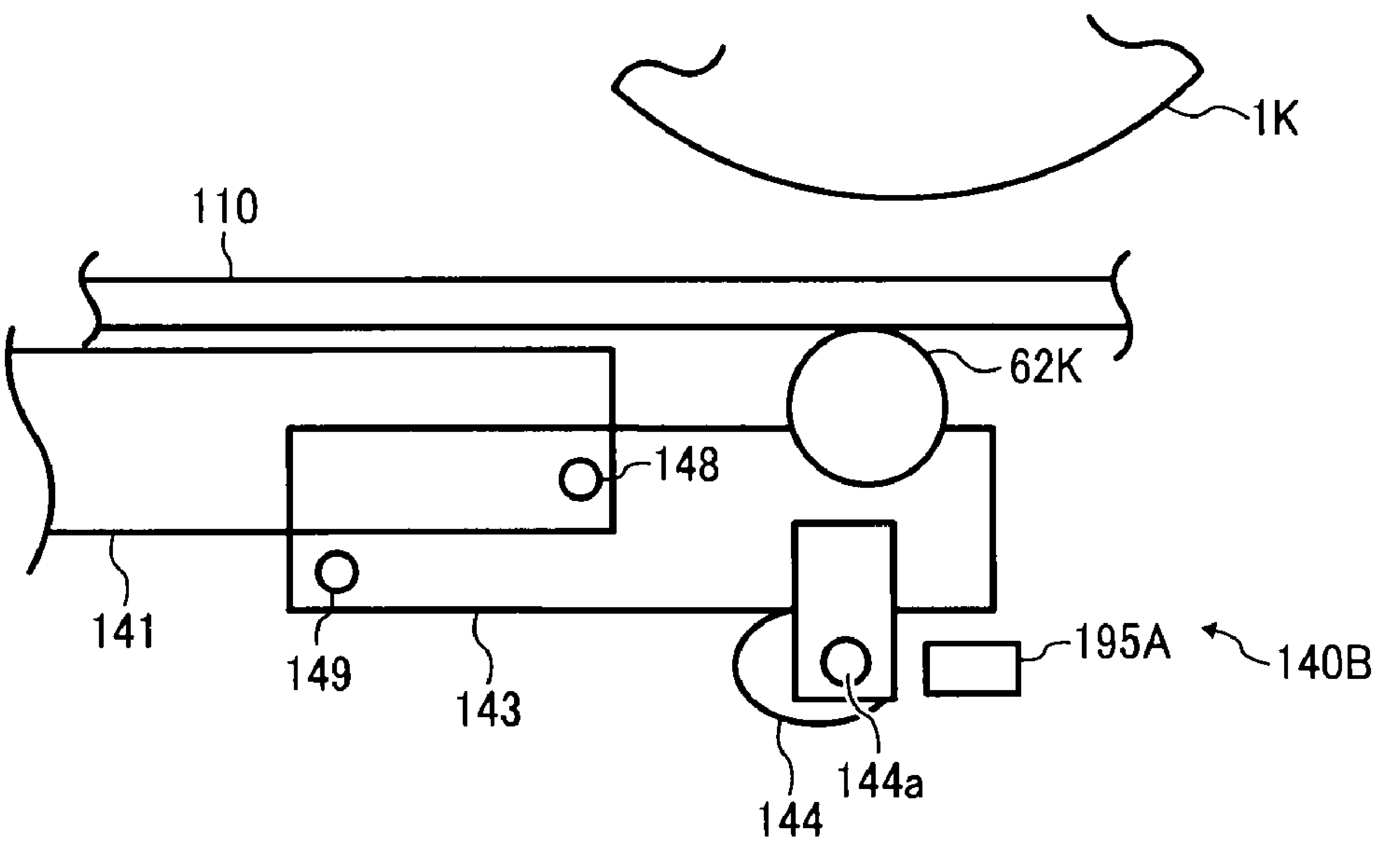


FIG. 25

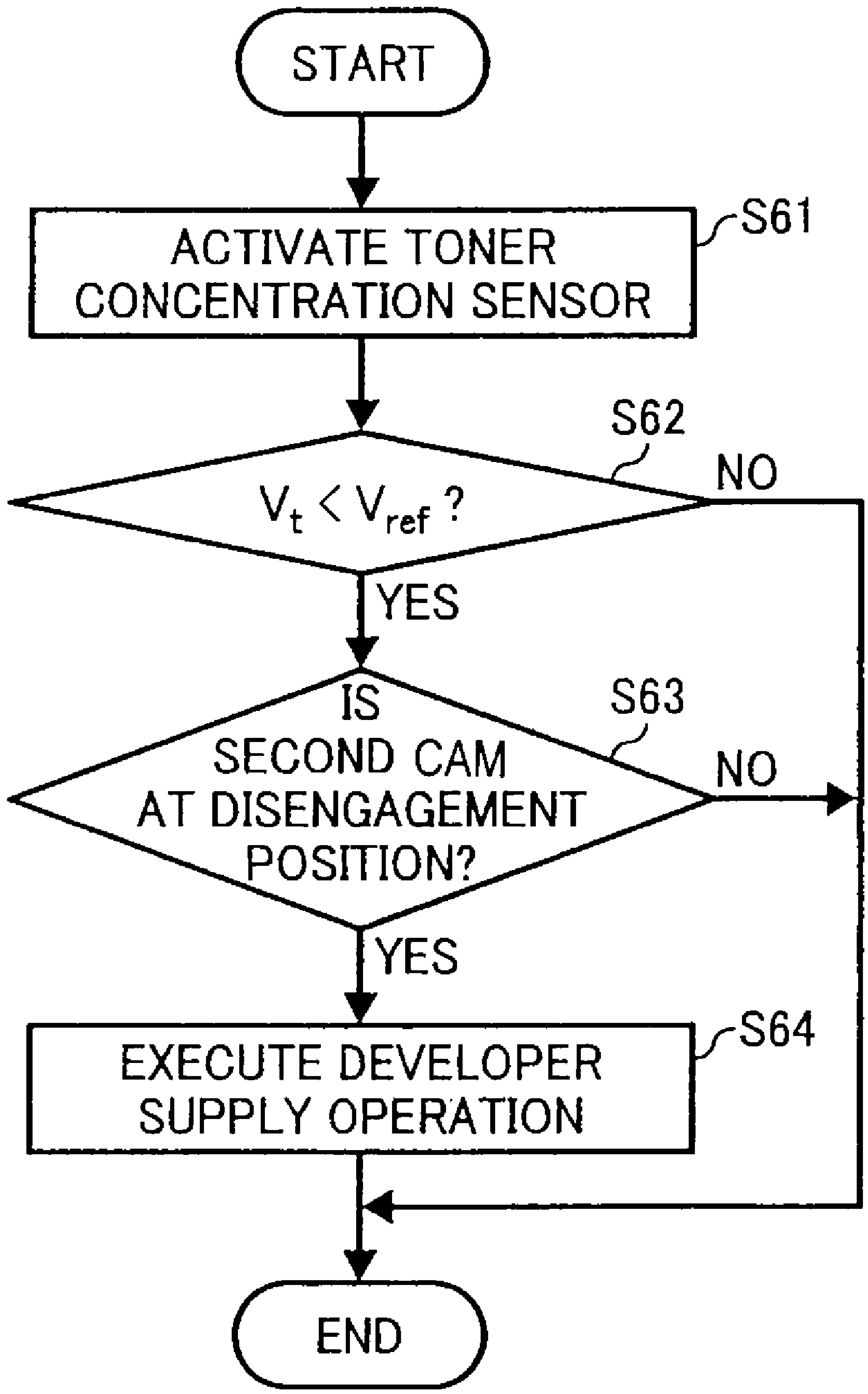

START
ACTIVATE TONER CONCENTRATION SENSOR
S61
S62
$V_t < V_{ref}$?
NO
YES
IS SECOND CAM AT DISENGAGEMENT POSITION?
S63
NO
YES
EXECUTE DEVELOPER SUPPLY OPERATION
S64
END

FIG. 26

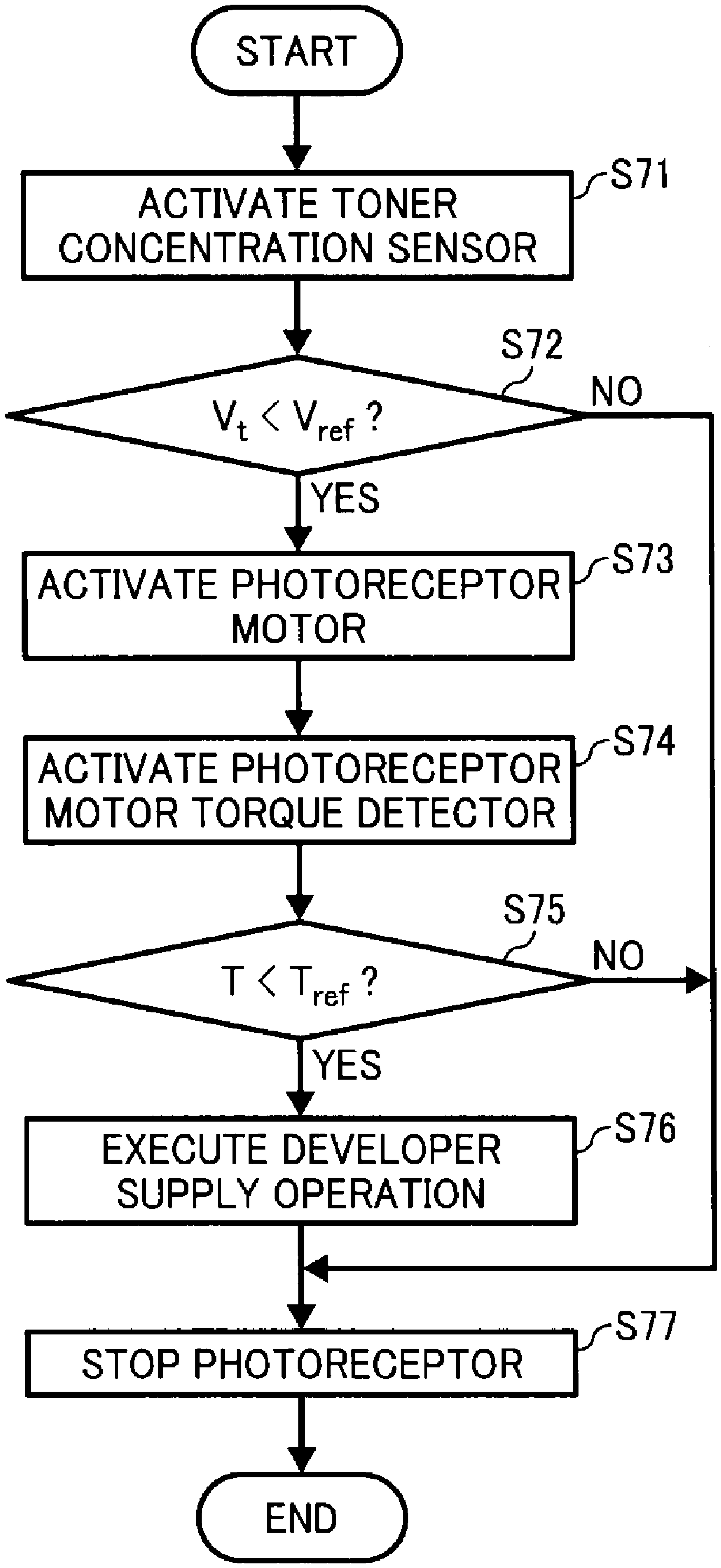
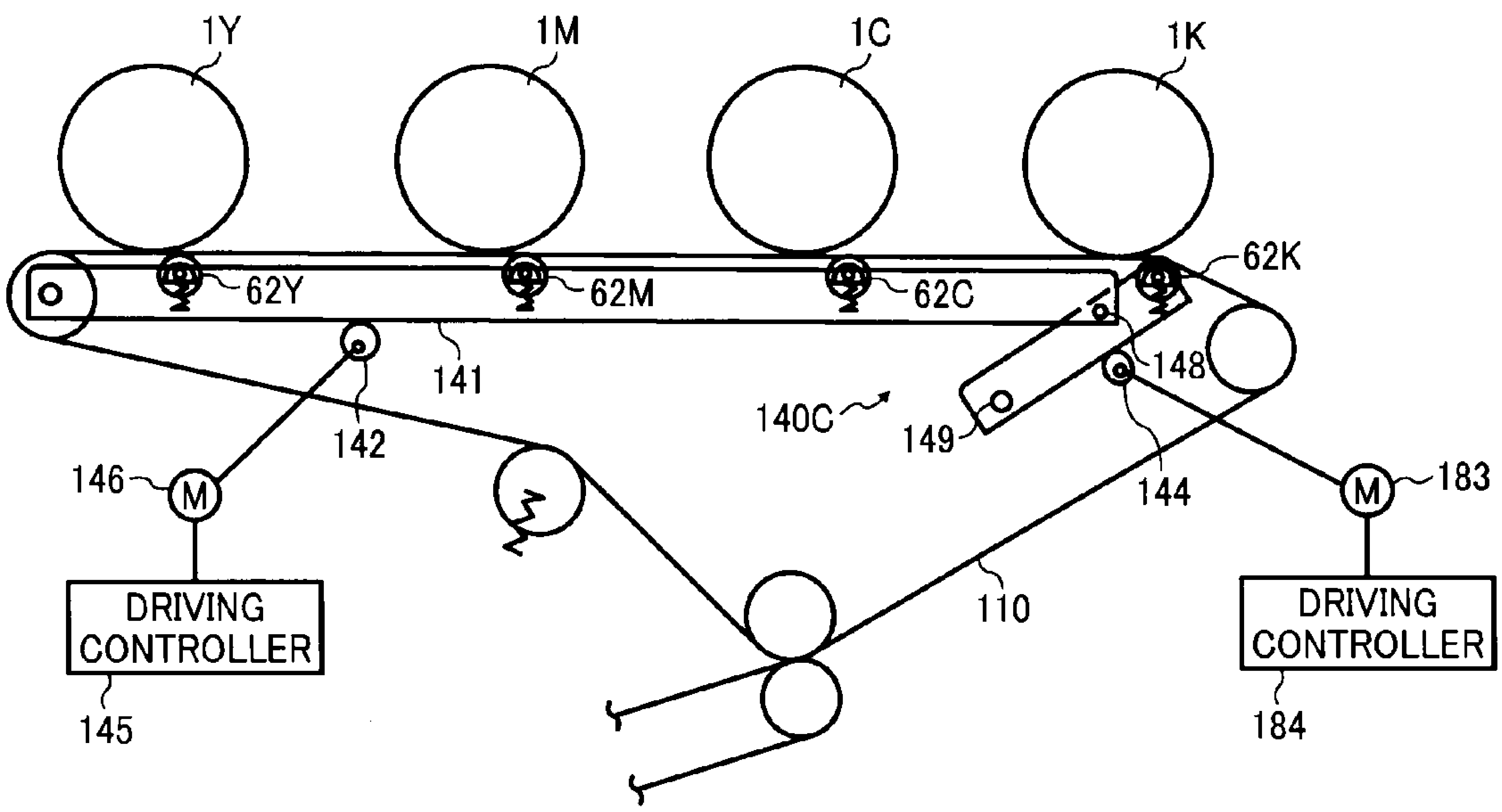

START
ACTIVATE TONER CONCENTRATION SENSOR
S71
S72
$V_t < V_{ref}$?
NO
YES
ACTIVATE PHOTORECEPTOR MOTOR
S73
ACTIVATE PHOTORECEPTOR MOTOR TORQUE DETECTOR
S74
S75
$T < T_{ref}$?
NO
YES
EXECUTE DEVELOPER SUPPLY OPERATION
S76
STOP PHOTORECEPTOR
S77
END

FIG. 27


1Y
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1C
1K
62Y
62M
62C
62K
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142
140C
148
149
144
146
M
183
DRIVING CONTROLLER
145
110
DRIVING CONTROLLER
184

FIG. 28

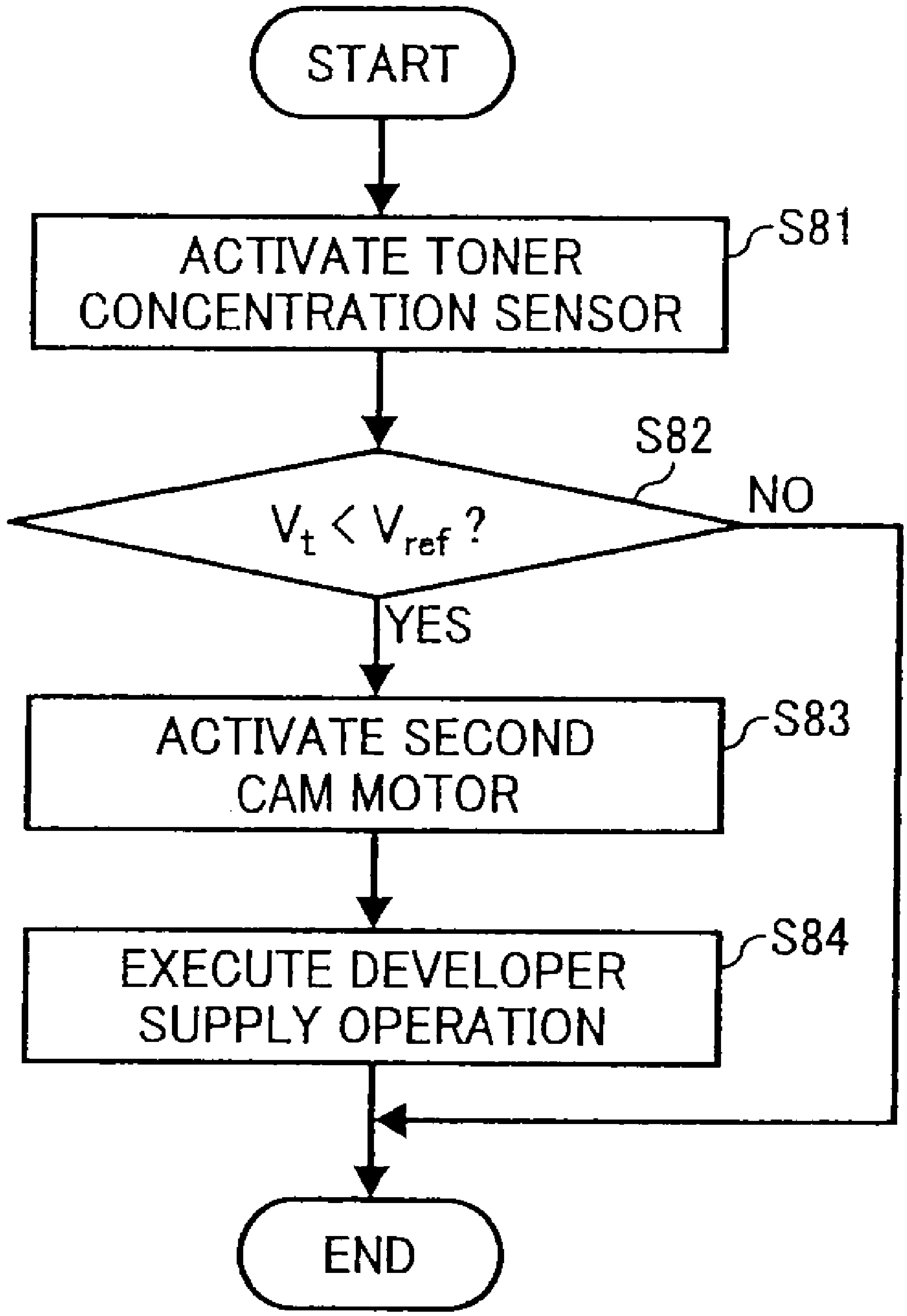
START
ACTIVATE TONER CONCENTRATION SENSOR
S81
S82
$V_t < V_{ref}$?
NO
YES
ACTIVATE SECOND CAM MOTOR
S83
EXECUTE DEVELOPER SUPPLY OPERATION
S84
END

IMAGE FORMING APPARATUS AND DEVELOPER SUPPLY METHOD THEREFOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent specification claims priority from Japanese Patent Application No. 2007-275555, filed on Oct. 23, 2007 in the Japan Patent Office, the entire contents of which are hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to an image forming apparatus, such as a facsimile machine, a copier, a printer, a multifunction machine including at least two of those functions, etc., and a developer supply method therefor.

2. Discussion of the Background

In general, an electrophotographic image forming apparatus, such as a copier, a printer, a facsimile machine, a multifunction machine including at least two of those functions, etc., includes an image forming mechanism for forming an electrostatic latent image on an image carrier, developing the latent image with developer, and transferring the developed image (toner image) onto a recording medium. As the developer, two-component developer in which toner and magnetic carrier are mixed is widely used.

The electronographic image forming apparatus has a developing unit, which typically includes a developing roller serving as a developer carrier that supplies the image carrier with the developer. The developing roller is partly exposed from an opening in the developing unit, and therefore, in such an image forming apparatus, the developer might spill out from the opening in the developing unit, particularly if a developer container part of the developing unit is filled with the developer before shipment and the developer container is shaken or the image forming apparatus tilts during transport. Further, the developer might deteriorate by being exposed to air. Therefore, the developer is typically put in the developer container part at a user's site.

In addition, because the magnetic carrier deteriorates over time and thus development capability is impaired with repeated use of the two-component developer, the developer including the degraded magnetic carrier should be periodically replaced.

As a typical developer replacement method, maintenance personnel visit the user each given cycle in order to collect the degraded developer and replenish the developing unit with unused developer. human error is inherent in such a method.

Herein, human error means the maintenance personnel might supply unused developer to the developer container part without removing the degraded developer therefrom, which is hereinafter referred to as redundant replenishment. Further, the maintenance personnel might forget having already filled it with the developer, and supply redundant developer to a developing unit of a newly installed image forming apparatus or a developing unit from which the degraded developer is removed.

As another example of human error, in a case of a color image forming apparatus including multiple developing units respectively corresponding to multiple color toners, the maintenance personnel might set a developer bottle of the wrong color to a developer supply port of the developing unit to which unused developer is to be supplied.

If redundant replenishment occurs, developer will spill over from the developing unit, and the developer remaining in the developer bottle will be spilled over the image forming apparatus when the developer bottle is removed from the developing unit, which might contaminate and damage the image forming apparatus.

Accordingly, there is a need to prevent such human error, as well as shorten a time period required to fill the developing unit with the developer and distribute the developer uniformly therein.

SUMMARY OF THE INVENTION

In view of the foregoing, in one illustrative embodiment of the present invention, an image forming apparatus includes an latent image carrier configured to carry a latent image thereon, a developing unit disposed facing the latent image carrier to develop the latent image with developer, a developer container configured to contain the developer and be attached to the image forming apparatus, a developer detector configured to detect the presence of the developer in the developing unit, and a developer supply controller. The developer supply controller prohibits supply of the developer from the developer container to the developing unit when the developer detector detects that the developer is present in the developing unit.

Another illustrative embodiment of the present invention describes a developer supply method used in the image forming apparatus described above. The developer supply method includes determining whether or not the developer is present in the developing unit, and prohibiting supply of the developer to the developing unit from the developer container when the developer is determined to be present therein.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** schematically illustrates a configuration of an image forming apparatus according to an illustrative embodiment of the present invention;

FIG. **2** schematically illustrates configurations of a developing unit and a photoreceptor;

FIG. **3** schematically illustrates a flow of developer inside the developing unit shown in FIG. **2**;

FIG. **4** is a perspective view illustrating the developing unit shown in FIG. **2**;

FIG. **5** is a perspective view illustrating a toner supply unit;

FIG. **6** is a cross section view illustrating the toner supply unit shown in FIG. **5**;

FIG. **7** is a perspective view illustrating a toner bottle;

FIG. **8** illustrates setting of a black toner bottle on the toner supply unit shown in FIG. **5**;

FIG. **9** is a perspective view of the image forming apparatus shown in FIG. **1**;

FIG. **10** illustrates a full engagement mode in which an intermediate transfer belt contacts all photoreceptors;

FIG. **11** illustrates a partial disengagement mode in which the intermediate transfer belt contacts only the photoreceptor for black;

FIG. **12** illustrates a full disengagement mode in which the intermediate transfer belt is disengaged from all photoreceptors;

FIG. **13** illustrates the image forming apparatus from which the toner supply unit shown in FIG. **5** is removed;

FIG. **14** illustrates a lever attached to a shaft of a second disengagement cam;

FIG. **15** illustrates a developer bottle set on a toner supply port of the developing unit shown in FIG. **2**;

FIG. **16** is a block diagram illustrating main elements of electrical circuitry of the image forming apparatus shown in FIG. **1**;

FIG. **17** illustrates a basic procedure to execute a developer supply mode;

FIG. **18** illustrates a procedure to execute a developer supply mode using a toner concentration sensor;

FIG. **19** illustrates a procedure to execute a developer supply mode using a development motor torque detector;

FIG. **20** illustrates a procedure to execute a developer supply mode using a toner adhesion detector;

FIG. **21** illustrates a basic procedure to execute a developer supply mode including detection of a position of the intermediate transfer belt;

FIGS. **22**A and **22**B illustrate a disengagement detector according to an illustrative embodiment;

FIG. **23** illustrates a procedure to execute a developer supply mode using the disengagement detector shown in FIGS. **22**A and **22**B;

FIGS. **24**A and **24**B illustrate a disengagement detector according to another illustrative embodiment;

FIG. **25** illustrates a procedure to execute a developer supply mode using the disengagement detector shown in FIGS. **24**A and **24**B;

FIG. **26** illustrates a procedure to execute a developer supply mode according to another illustrative embodiment;

FIG. **27** illustrates a second disengagement motor configured to rotate the second disengagement cam; and

FIG. **28** illustrates a procedure to execute a developer supply mode using the second disengagement motor shown in FIG. **27**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In describing preferred embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve a similar result.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views thereof, and particularly to FIG. **1**, an image forming apparatus according to an illustrative embodiment of the present invention is described. The image forming apparatus in the present embodiment is a tandem color laser copier in which multiple photoreceptors are arranged in parallel to each other.

FIG. **1** schematically illustrates a configuration of a tandem color laser copier **100** (hereinafter simply "copier **100**") according to the present embodiment. The copier **100** includes a print unit **150**, a sheet feeder **200** on which the print unit **150** is located, a scanner **300** fixed on the printer **150**, and an automatic document feeder (ADF) **400** fixed on the scanner **300**.

The print unit **150** includes an image forming unit **20**, an optical writing unit **21**, an intermediate transfer unit **17**, a secondary transfer unit **22**, a pair of registration rollers **49**, a belt type fixer **25**, and a sheet reverse unit **28** for reversing a transfer sheet that is a recording medium in a duplex print mode. The image forming unit **20** includes four process cartridges **18**Y, **18**M, **18**C, and **18**K for forming yellow, magenta, cyan, and black images, respectively.

It is to be noted that the reference characters Y, M, C, and K respectively represent yellow, magenta, cyan, and black, and may be omitted in the description below when color discrimination is not required.

Each process cartridge **18** includes a drum-shaped photoreceptor and a developing unit **4**. The optical writing unit **21** includes a light source, a polygon mirror, an f-θ lens, and a reflection mirror, and directs a laser light (exposure light) onto each photoreceptor **1** according to image data.

The process cartridge **18**K is described below in further detail.

The process cartridge **18**K further includes a charger, a drum cleaner that in the present embodiment is a cleaning blade, and a discharger, although not illustrated in FIG. **1**. After the charger charges a surface of the photoreceptor **1**Y uniformly, the optical writing unit **21** directs a modulated and deflected laser light thereonto, and thus electrical potential of the exposed portions of the surface of the photoreceptor **1**Y is attenuated. Thus, an electrostatic latent image for yellow is formed thereon. Subsequently, the developing unit **4** develops the latent image into a yellow toner image.

Then, the yellow toner image is transferred from the photoreceptor **1**Y onto an intermediate transfer belt **110** serving as an intermediate transfer member by the intermediate transfer unit **17** serving as a transferor. Subsequent to this primary transfer process, the drum cleaner cleans the surface of the photoreceptor **1**Y, and the discharger removes electricity remaining thereon. Then, the surface of the photoreceptor **1**Y is again charged uniformly by the charger and thus initialized.

The sequence of processes described above are similarly performed in the process cartridges **18**M, **18**C, and **18**K, and thus magenta, cyan, and black toner images are respectively formed therein.

It is to be noted that the four process cartridges **18**Y, **18**M, **18**C, and **18**K have a similar configuration and operates in a similar manner except the color of toners used therein, and thus descriptions of the process cartridges **18**M, **18**C, and **18**K are omitted.

The intermediate transfer unit **17** is described below in further detail.

The intermediate transfer unit **17** includes the intermediate transfer belt **110**, a belt cleaner **90**, a roller **14**, a driving roller **15**, a back-up roller **16**, and primary transfer rollers **62**Y, **62**M, **62**C, and **62**K.

The intermediate transfer belt **110** is looped around the roller **14**, the driving roller **15**, and the back-up roller **16**, and endlessly travels clockwise in FIG. **1** with the driving roller **15** that is driven by a motor.

The primary transfer rollers **62**Y, **62**M, **62**C, and **62**K are located to contact an inner surface of the intermediate transfer belt **110** and receives bias voltage from a power source. Further, the primary transfer rollers **62**Y, **62**M, **62**C, and **62**K press the intermediate transfer belt **110** against the photoreceptors **1**Y, **1**M, **1**C, and **1**K, respectively forming primary transfer nips where primary transfer electrical fields are formed between the photoreceptors **1**Y, **1**M, **1**C, and **1**K and the primary transfer rollers **62**Y, **62**M, **62**C, and **62**K.

The yellow toner image formed on the photoreceptor **1**Y is transferred onto the intermediate transfer belt **110** due to effects of the primary transfer electrical field and a nip pressure. On the yellow toner image, the magenta, cyan, and black toner images respectively formed on the photoreceptors **1**M, **1**C, and **1**K are superimposed one on another in the primary transfer process. Thus, a multicolor image, which in the present embodiment is a four-color image, is formed on the intermediate transfer belt **110**.

The four-color image is then transferred by the secondary transfer unit **22** onto a transfer sheet in a secondary transfer nip. The belt cleaner **90** faces the driving roller **15** via the intermediate transfer belt **110**, and removes toner remaining on the intermediate transfer belt **110** that has passed through the secondary transfer nip.

The secondary transfer unit **22** is described below in further detail.

The secondary transfer unit **22** is located beneath the intermediate transfer unit **17** in FIG. **1**, and includes a transport belt **24** looped around a pair of rollers **23**. The transport belt **24** endlessly travels counterclockwise in FIG. **1** with rotation of at least one of the rollers **23**. The intermediate transfer belt **110** and the transport belt **24** are sandwiched between the back-up roller **16** and the roller **23** on the right, forming the secondary transfer nip therebetween. Further, the right side roller **23** receives a secondary transfer bias having a polarity opposite a polarity of the toner from a power source.

With the secondary transfer bias, a secondary transfer electrical field for causing the four-color image on the intermediate transfer belt **110** to move to the side of the roller **23** is formed in the secondary transfer nip. Thus, due to effects of the secondary transfer electrical field and a nip pressure, the four-color image is transferred onto the transfer sheet that is forwarded by the registration rollers **49** in synchronization with the four-color image.

It is to be noted that, instead of the secondary transfer method in which the secondary transfer bias is applied to the roller **23** as described above, alternatively, a method using a charger that charges the transfer sheet in a non-contact manner can be adopted.

The sheet feeder **200** includes a paper bank **43** in which multiple sheet cassettes **44** are arranged one above another, and a sheet feed path **46** provided with multiple pairs of transport rollers **47**. Each sheet cassette **44** contains a stack of transfer sheets against which a feed roller **42** presses from above. The transfer sheets are fed from the top with rotation of the feed roller **42**, and a separation roller **45** separates the transfer sheets one by one.

Then, the sheet is transported along the sheet feed path **46** to the registration rollers **49**. While the registration rollers **49** sandwich the transfer sheet therebetween, the intermediate transfer belt **110** transports the four-color image to the secondary transfer nip. When the registration rollers **49** forwards the transfer sheet timely so that the transfer sheet laps over the four-color image in the secondary transfer nip, the four-color image is transferred from the intermediate transfer belt **110** onto a first side of the transfer sheet in the secondary transfer nip. This image becomes a full-color image (hereinafter also "toner image") on the white transfer sheet. Subsequently, the transport belt **24** transports the transfer sheet to the fixer **25**.

The fixer **25** includes a belt unit including a fixing belt **26** looped around two rollers, and a pressure roller **27** that presses against one of those rollers. The fixing belt **26** contacts the pressure roller **27**, forming a fixing nip in which the transfer sheet forwarded by the transport belt **24** is sandwiched. A heat source is provided inside the roller against which the fixing roller **27** presses so as to heat the fixing belt **26**, which heats the transfer sheet. Thus, the full-color image is fixed on the transfer sheet with heat from the transfer belt **26** and a nip pressure.

Then, the transfer sheet whose first side carries the fixed toner image is either stacked on a stack part **57** provided outside a side plate of the print unit **150** on the left in FIG. **1** or returned to the secondary transfer nip so that a toner image is formed on a second side thereof in the duplex print mode.

A copying operation using the copier **100** is described below with reference to FIG. **1**.

For example, a stack of original documents is set on a document table **30** of the ADF **400**. Alternatively, when the original documents are bound like a book, the ADF **400** is lifted to expose a contact glass **32** of the scanner **300**, the original documents are set on the contact glass **32**, and then the ADF **400** is lowered to hold the original documents.

Then, when a user presses a start switch, the ADF **400** forwards the original documents set on the document table **30** one by one onto the contact glass **32**, and then the scanner **300** starts reading image information of the original documents. When the original documents are set on the contact glass **32**, pressing the start switch causes the scanner **300** to immediately read the original documents.

The scanner **300** includes a first carriage **33** including a light source, a second carriage **34** including a mirror, an imaging lens **35**, and a reading sensor **36**. In a document reading operation, both the first carriage **33** and the second carriage **34** start traveling, and the light source emits light toward the original document. The light is then reflected by the original document, and the mirror in the second carriage **34** further reflects the light to the imaging lens **35**. After passing through the imaging lens **35**, the light enters the reading sensor **36**, and thus the reading sensor **36** obtains image information based on the light.

In parallel to the document reading operation described above, components of the process cartridges **18**, the intermediate transfer unit **17**, the secondary transfer unit **22**, and the fixer **25** are activated. The optical writing unit **21** is controlled so as to form electrostatic latent images for yellow, magenta, cyan, and black on the photoreceptors **1**Y, **1**M, **1**C, and **1**K, respectively, according to the image information obtained by the reading sensor **36**. Then, the latent images are developed into toner images and further transferred onto the intermediate transfer belt **110**, forming a four-color image (toner image).

Further, simultaneously with the start of the document reading operation described above, the sheet feeder **200** starts to feed the transfer sheets. One of the feed rollers **42** is selected and rotates to feed the transfer sheets from the sheet cassette **44** corresponding thereto, and the transfer sheets are transported along the sheet feed path **46** one by one, separated by the separation roller **45**. Alternatively, the transfer sheets can be fed from a manual feed tray **51**. In this case, a manual feed roller **50** is selected to rotate, and the transfer sheets are transported along a manual feed path **53** one by one, separated by a separation roller **52**.

When forming a multicolor image using at least two different color toners, the copier **100** holds an upper side of the intermediate transfer belt **110** substantially horizontally so as to contact all photoreceptors **1**.

By contrast, when forming a monochrome image using only black toner, the upper side of the intermediate transfer belt **110** is disengaged from the photoreceptors **1**Y, **1**M, and **1**C by inclining the intermediate transfer belt **110** so that its left side is lowered. Then, only the photoreceptor **1**K is rotated counterclockwise in FIG. **1** and a black image is formed thereon. In each of the process cartridges **18**Y, **18**M, and **18**C, the developing unit **4** is deactivated as well so as to save the developer and prevent wear of the photoreceptor **1**.

Although not shown in FIG. **1**, the copier **100** further includes a controller **198** for controlling operations of respective parts thereof and an operating unit (operation display)

194 including a display and various keys, and these are described below with reference to FIG. **16**.

Regarding single print modes in which an image is formed only one side of the transfer sheet, the copier **100** can offer three different mode: a direct discharge mode, a reverse discharge mode, and a reverse decal discharge mode. The user can select one of the modes by sending a command to the controller **198** from the operating unit **194**.

FIG. **2** is an end-on view illustrating the developing unit **4** and the photoreceptor **1** included in each process cartridge **18** shown in FIG. **1**.

Referring to FIGS. **1** and **2**, while the photoreceptor **1** rotates in a direction indicated by arrow G, the charger charges the surface of the photoreceptor **1** and an electrostatic latent image is formed thereon with the laser light emitted from the optical writing unit **21**. Further, the developing unit **4** supplies the latent image with the toner, forming a toner image.

As shown in FIG. **2**, the developing unit **4** includes a developer container part and a developing roller **5** serving as a developer carrier that supplies the electrostatic latent image on the photoreceptor **1** with the toner while rotating in a direction indicated by arrow I.

The developer container part (hereinafter also "developer transport path") forms a collection path **7**, a supply path **9**, and an agitation path **10** provided with a collection screw **6**, a supply screw **8**, and an agitation screw **11**, respectively. Each of the collection screw **6**, the supply screw **8**, and the agitation screw **11** serves as a developer transporter and a blade part is provided on its rotary shaft so as to transport the developer in an axial direction by rotating.

While supplying the toner to the developing roller **5**, the supply screw **8** in the supply path **9** transports the developer toward a back side of the sheet on which FIG. **2** is drawn, that is, in a direction perpendicular to and rearward of the sheet on which FIG. **2** is drawn. The developer supplied to the developing roller **5** is adjusted to have a desired or given thickness by a developer doctor **12**, serving as a developer regulator, located downstream from a portion where the developing roller **5** faces the supply screw **8** in the direction indicated by arrow I in which the developing roller **5** rotates (hereinafter also "developing roller rotational direction").

The collection path **7** is located downstream from a development area where the developing roller **5** faces the photoreceptor **1** in the developing roller rotational direction. The developing unit **4** further includes a development bias applicator configured to apply a developing bias for forming an electrical field that causes the toner to adhere to the electrostatic latent image on the photoreceptor **1**.

The collection screw **6** collects the developer that has passed through the development area and transports the collected developer in a direction identical or similar to the direction in which the developer is transported (hereinafter simply "developer transport direction") by the supply screw **8**.

The developing roller **5** and the supply path **9** are arranged laterally, and the collection path **7** is located beneath the developing roller **5**.

The agitation path **10** including the agitation screw **11** is located beneath the supply path **9**, parallel to the collection path **7**. While agitating the developer, the agitation screw **11** transports the developer toward a front side of the sheet on which FIG. **2** is drawn, which is a direction opposite to the developer transport direction of the supply screw **8**.

The developing unit **4** further includes a first separation wall **133** and a second separation wall **134**, serving as separators, and a toner concentration sensor **191**. The copier **100** further includes a toner adhesion sensor **190** serving as a toner adhesion detector. The first separation wall **133** includes a portion separating the supply path **9** from the agitation path **10** and a portion separating the supply path **9** from the collection path **7**. The second separation wall **134** separates the collection path **7** from the agitation path **10**.

For example, the toner adhesion detector **190** is located downstream from the development area in the direction indicated by arrow G in which the photoreceptor **1** rotates, and faces the photoreceptor **1** at a location in the axial direction that is within the width of the developing roller **5**. The toner concentration sensor **191** is located on a bottom portion of the agitation path **10**, in a downstream portion in the developer transport direction of the agitation screw **11**, which is a back side portion in FIG. **2**.

Circulation of the developer in the developing unit **4** is described below with reference to FIGS. **2** and **3**.

FIG. **3** illustrates a flow of the developer inside the developing unit **4**, and arrows therein indicate directions in which the developer flows. Further, the back surface and the front side in FIG. **2** are located on the left and right in FIG. **3**, respectively.

The first separation wall **133** includes openings **91** and **92**, shown in FIG. **3**, respectively provided in both end portions in the axial direction thereof, enabling the supply path **9** and the agitation path **10** to communicate with each other. The second separating wall **134** includes an opening **93** provided in an end portion on the left in FIG. **3** so as to connect the collection path **7** and the agitation path **10**.

The developer that has passed through the development area is collected in the collection path **7** and transported to the left in FIG. **3**. Subsequently, the developer is further transported to the agitation path **10** through the opening **93** of the first separation wall **133**, which is located in a non-image area.

The first separation wall **133** has no opening in the portion separating the supply path **9** and the collection path **7**, and thus the supply path **9** and the collection path **7** are kept separate and do not communicate with each other.

As shown in FIG. **3**, a toner supply port **95** is provided in an upper portion of the agitation path **10** near the opening **93**, and premixed toner including magnetic carrier is supplied to the agitation path **10** through the toner supply port **95** as indicated by arrow L, as needed.

The developer is transported from the agitation path **10** to the supply path **9** as indicated by arrow D in FIG. **3**, where the supply screw **8** transports the developer downstream, that is, to the right in FIG. **3**, while supplying the developing roller **5** with the toner. The developer that is not used for development (hereinafter also "excess developer") is transported to a downstream end portion of the supply path **9**.

Then, the excess developer is transported to the agitation path **10** as indicated by arrow E through the opening **92** (hereinafter also "excess developer opening **92**") provided on the first separation wall **133**, located on the left in FIG. **3**.

By contrast, the developer supplied to the developing roller **5** is collected in the collection path **7** as the developing roller **5** rotates, and then the collected developer (hereinafter also "used developer") is transported by the collection screw **6** to a downstream end portion of the collection path **7** located on the left in FIG. **3**. The collected developer is further transported to the agitation path **10** as indicated by arrow F though the opening **93** (hereinafter also "collection opening **93**") provided on the second separation wall **134**.

Subsequently, in the agitation path **10**, the agitation screw **11** agitates the excess developer and the collected developer as well as transports the agitated developer downstream, which is upstream in the developer transport direction of the supply screw **8**. In a downstream end portion of the agitation path **10**, the developer is supplied to the supply path **9** as indicated by arrow D through the opening **91** provided on the first separation wall **133** (hereinafter also “supply opening **91**”).

Thus, in the agitation path **10**, the agitation screw **11** agitates and transports the collected developer, the excess developer, and the premixed toner (hereinafter also “unused toner”) supplied through the toner supply port **95** in the opposite direction to the developer transport direction of the collection screw **6** and the supply screw **8**. Then, the developer is transported from the downstream end portion of the agitation path **10** to an upstream portion of the supply path **9** that communicate with each other.

It is to be noted that the toner is supplied according to an output from the toner concentration sensor **191** that can be provided, for example, in a downstream portion of the agitation path **10**.

As described above, the developing unit **4** shown in FIG. **3** includes the supply path **9** and the collection path **7** so that supply and collection of the developer can be performed in separate paths, preventing the used developer from entering the supply path **9** directly. Thus, the toner concentration in the developer to be supplied to the developing roller **5** does not decrease as the developer is transported downstream in the supply path **9**.

Further, the developer **4** includes the collection path **7** and the agitation path **10** so that collection and agitation of the developer can be performed in separate paths, and thus the used developer can be fully mixed with the excess developer and the unused developer to supply well-agitated developer to the supply path **9**.

Consequently, image density during development can be kept constant by maintaining the toner concentration in the developer as well as fully agitating the developer.

Location to supply the premixed toner to the developer transport path including the supply path **9**, the agitation path **10**, and the collection path **7** is described below in further detail.

FIG. **4** is a perspective view of the developer **4** shown in FIGS. **2** and **3**.

With reference to FIGS. **3** and **4**, the toner supply port **95** is located in the upper portion of an upstream end portion of the agitation path **10**, which is outside an end portion of the developing roller **5** in the axial direction.

It is to be noted that the location of the toner supply port **95** is not limited to that described above, and alternatively, the toner supply port **95** may be provided on an upper portion of the downstream end portion of the collection path **7**, for example. Alternatively, the toner supply port **95** may be provided above the collection opening **93** where the developer is transported from the collection path **7** to the agitation path **10**. Because the newly supplied developer and the existing developer can be easily mixed together around the collection opening **93**, the developer can be agitated more effectively by providing the toner supply port **95** there.

A toner supply unit to supply the premixed toner to the developing unit **4** through the toner supply port **95** is described below.

The copier **100** shown in FIG. **1** further includes a toner supply unit **500**. FIG. **5** is a perspective view illustrating the toner supply unit **500** including multiple toner bottles **120** serving as toner containers or powder containers, and FIG. **6** is a schematic illustration of a configuration thereof. Further, FIG. **7** is a perspective view illustrating the toner bottle **120**, FIG. **8** illustrates installation of the toner bottle **120**, and FIG. **9** is a perspective view of the copier **100**.

Referring to FIG. **5**, each toner bottle **120** contains the premixed toner including the toner and the carrier. The toner concentration of the premixed toner is higher than that of the developer in the developing unit **4**. In FIG. **5**, reference character T_f indicates a flow of the premixed toner.

As shown in FIG. **5**, the multiple toner bottles **120** for respective colors are arranged in the copier **100** that is a tandem image forming apparatus. The toner supply unit **500** further includes supply units each including a toner pump **60**, a toner supply tube **65**, and a sub hopper **68** for each color, and each toner bottle **120** is connected to the supply unit. The developing unit **4** is located beneath the supply unit. The toner supply unit **500** further includes a nozzle **80** for each color whose tip portion is inserted into the toner bottle **120**, and each toner pump **60** is connected to a driving motor **66**.

As shown in FIG. **6**, the toner supply unit **500** further includes a suction port **63**, a universal joint **64**, and a toner outlet **67**. The toner pump **60** in the present embodiment is either a mohno-pump, which is a type of screw pump, or a suction-type uniaxial eccentric screw pump, and includes a rotor **61** and a cylindrical stator **69** whose inner surface includes a spiral groove as main components. The rotor **61** is the shape of a shaft having a circular cross-section twisted into a spiral, and is connected to the driving motor **66** via a driving transmission and the universal joint **64**. The rotor **61** transports the premixed toner axially by rotating inside the stator **69**. The stator **69** is elastic and includes a hole whose cross-section is an ellipse twisted into a spiral. The pitch of the spiral of the stator **69** is twice that of the spiral of the rotor **61**.

By engaging the rotor **61** with the stator **69** and then rotating the rotor **61**, the premixed toner is transported through a space formed between the rotor **61** and the stator **69**. In other words, in the toner pump **60**, one of the main components is caused to slidably move as the other main component is rotated, generating a negative pressure at the suction port **63**, which causes airflow inside the toner supply tube **65**.

More specifically, when the rotor **61** is rotated, the premixed toner in the toner bottle **120** enters the toner pump **60** through the suction port **63**, is aspirated and transported from the left to the right in FIG. **6**, and then supplied to the developing unit **4** through the toner outlet **67**, the sub hopper **68**, and the toner supply port **95**.

It is to be noted that the configuration of the toner pump **60** is not limited to the description above, and various known pumps such as those disclosed in Japanese Patent Publication No. 2000-098721 can be used, the contents of which are hereby incorporated by reference herein.

Referring to FIGS. **6** and **7**, each toner bottle **120** includes a toner container **121**, a toner outlet coupling **122** serving as a single powder outlet, and a base **130** attached to the toner outlet coupling **122**.

Referring to in FIGS. **8** and **9**, the toner supply unit **500** further includes four bottle holders **75**Y, **75**M, **75**C, and **75**K, each of which can pivot on a rotary shaft so as to partly disengage from the toner supply unit **500**. As shown in FIG. **9**, outer side surface **76**Y, **76**M, **76**C, and **76**K of the bottle holders **75**Y, **75**M, **75**C, and **75**K are exposed on a front side of the copier **100**. The bottle holders **75**Y, **75**M, **75**C, and **75**K hold the toner bottles **120**Y, **120**M, **120**C, and **120**K, respectively. The toner supply unit **500** further includes multiple screw holes **77** and **78** into which screws are respectively inserted, attaching the toner supply unit **500** to the side walls of the copier **100**.

Setting of the toner bottle **120** on the bottle holder **75** is described below.

Referring to FIGS. **6** and **8**, for example, to set the toner bottle **120**K on the bottle holder **75**K, the user unlocks and pivots the bottle holder **75**K so that the bottle holder **75**K rotates down and out on the front side of the copier **100**. Then, the user holds the toner bottle **120**K with the side of the base **130** facing down and inserts the toner bottle **120**K down the bottle holder **75**K.

When the toner bottle **120** is on the bottle holder **75**, the tip portion of the nozzle **80**, which serves as a connecter of the copier **100** to be connected to the base **130**, is inserted into the toner bottle **120**. Thus, the toner outlet coupling **122** and a toner inlet of the nozzle **80** communicate with each other. The nozzle **80** includes a joint to be connected to the toner supply tube **65** that communicates with the toner pump **60**, and further, the toner pump **60** communicates with the developing unit **4** via the sub hopper **68**. Thus, when the toner bottle **120** is set on the bottle holder **75**, the toner bottle **120** communicates with the developing unit **4**.

Next, a disengagement mechanism to disengage the intermediate transfer belt **110** from the photoreceptors **1** is described below.

FIG. **10** illustrates a full engagement mode, in which the intermediate transfer belt **110** supported by the multiple rollers contacts all the photoreceptors **1**Y, **1**M, **1**C, and **1**K.

Referring to FIG. **10**, a disengagement unit **140** includes a first arm **141**, a first disengagement cam **142**, a second arm **143**, a second disengagement cam **144**, a driving controller **145**, and a first disengagement motor **146**. The first arm **141** and the first disengagement cam **142** are for engaging or disengaging the intermediate transfer belt **110** with or from the photoreceptors **1**Y, **1**M, and **1**C simultaneously, and the second arm **143** and the second disengagement cam **144** are for engaging or disengaging the intermediate transfer belt **110** with or from the photoreceptor **1**K. The first disengagement cam **142** is rotated by the first disengagement motor **146** according to a control signal from the driving controller **145**. The second disengagement cam **144** can be manually rotated using a lever **147** (shown in FIG. **14**) that is attached to a tip portion of a shaft **144***a* of the second disengagement cam **144**.

It is to be noted that hereinafter the right and the left sides of the first arm **141** in FIGS. **10** through **12** are simply referred to as the right and the left sides of the first arm **141**.

An end portion of the first arm **141** is pivotally supported by a pivot point **148** provided on the second arm **143**, and the location of the pivot point **148** is closer to the primary transfer roller **62**K than a center portion of the second arm **143** in a longitudinal direction is. The second arm **143** is pivotally supported by a pivot point **149**, and the pivot point **148** provided on the second arm **143** swings as the second arm **143** pivots.

The driving roller **15** is provided on a left end portion of the first arm **141**, which is the side opposite the pivot point **148**. Further, the primary transfer rollers **62**Y, **62**M, and **62**C are located between the driving roller **15** and the pivot point **148** in a longitudinal direction of the first arm **141**, and rotatably supported and biased toward the photoreceptors **1**Y, **1**M, and **1**C simultaneously by pressure springs **163**Y, **163**M, and **163**C, respectively. A tension spring **13***a* biases a tension roller **13** provided to contact the intermediate transfer belt **110** from outside so as to tension the intermediate transfer belt **110**.

The first disengagement cam **142** contacts a portion of the first arm **141** located between the driving roller **15** and a center portion thereof in the longitudinal direction, on the side opposite the side of the primary transfer rollers **62**Y, **62**M, and **62**C. As the first disengagement cam **142** rotates, the first arm **141** pivots on the pivot point **148**, which causes the primary transfer roller **62**Y, **62**M, and **62**C to engage or disengage the intermediate transfer belt **110** with or from the photoreceptors **1**Y, **1**M, and **1**C simultaneously.

The second arm **143** is pivotally attached to a frame of the intermediate transfer unit **17** shown in FIG. **1** by the pivot point **149** provided on one portion thereof. The primary transfer roller **62**K is located on another end portion of the second arm **143** on the side opposite the pivot point **149**, and a pressure spring **163** rotatably supports the primary transfer roller **62**K, as well as biasing it toward the photoreceptors **1**K. The second disengagement cam **144** contacts the second arm **143** at a position between the primary transfer roller **62**K and the center portion in the longitudinal direction, on the side opposite the side of the photoreceptor **1**K. As the second disengagement cam **144** rotates, the second arm **143** pivots on the pivot point **149**, which causes the primary transfer roller **62**K to engage or disengage the intermediate transfer belt **110** with or from the photoreceptor **1**K.

FIG. **11** illustrates a partial disengagement mode, in which the intermediate transfer belt **110** engages only the photoreceptor **1**K and is disengaged from the photoreceptors **1**Y, **1**M, and **1**C.

When the first disengagement cam **142** makes a half revolution from the state illustrated in FIG. **10**, the first arm **141** pivots around the pivot point **148** downward in FIG. **10**, and thus the primary transfer rollers **62**Y, **62**M, and **62**C move away from the photoreceptors **1**Y, **1**M, and **1**C, respectively. In this state, the second disengagement cam **144** is at an engagement position so as to press the primary transfer roller **62**K against the photoreceptor **1**K via the intermediate transfer belt **110**. Accordingly, the intermediate transfer belt **110** disengages from the photoreceptors **1**Y, **1**M, and **1**C and engages only the photoreceptor **1**K as shown in FIG. **11**, and thus the intermediate transfer belt **110** enters the partial disengagement mode for forming monochrome black images.

In the partial disengagement mode, deterioration of the photoreceptors **1**Y, **1**M, and **1**C can be prevented or reduced because the intermediate transfer belt **110** does not contact them. Further, the photoreceptors **1**Y, **1**M, and **1**C can be deactivated, extending the life of the chargers, the developing units **4**, and the drum cleaners therefor as well as the photoreceptors **1**Y, **1**M, and **1**C.

FIG. **12** illustrates a full disengagement mode, in which the intermediate transfer belt **110** is disengaged from all the photoreceptors **1**Y, **1**M, **1**C, and **1**K.

When unused developer is supplied to an empty developing unit **4**, the intermediate transfer belt **110** is disengaged from all the photoreceptors **1**Y, **1**M, **1**C, and **1**K in the present embodiment. The intermediate transfer belt **110** is set to the full disengagement mode at the factory, and, at the user's site, the maintenance person rotates the second disengagement cam **144** using the lever **147** (shown in FIG. **14**) attached to the shaft **144***a* so as to set the intermediate transfer belt **110** to the partial disengagement mode shown in FIG. **11**.

When the second disengagement cam **144** makes a half revolution from the engagement position illustrated in FIG. **11** to a disengagement position, the second arm **143** pivots on the pivot point **149** clockwise in FIG. **11**, and accordingly the primary transfer roller **62**K descends away from the photoreceptor **1**K, disengaging the intermediate transfer belt **110** from the photoreceptor **1**K. That is, the intermediate transfer belt **110** is disengaged from all the photoreceptors **1**Y, **1**M, **1**C, and **1**K.

Further, in this state, the first arm **141** is inclined so that its right side on which the pivot point **148** is provided is lowered because the right side end portion is supported by the second arm **143**, and thus the first arm **141** moves downward in FIGS. **11** and **12** to a position parallel or substantially parallel to the position shown in FIG. **10**.

It is to be noted that, if the pivot point **148** of the first arm **141** is not connected to the second arm **143** as in the configuration described above, the first arm **141** would be inclined to the lower left in FIG. **12**, and thus the primary transfer roller **62**C would be closest to the corresponding photoreceptor **1** among the primary transfer rollers **62**Y, **62**C, **62**M, and **62**K. Accordingly, the distance between the intermediate transfer belt **110** and the photoreceptor **1**C would be shorter than the distance between the intermediate transfer belt **110** and either of the photoreceptors **1**Y and **1**M.

Replacement of the developer in the developing unit **4** is described below.

The developer in the developing unit **4** is replaced periodically because the developer, the carrier in particular, deteriorates over time while being used. Used developer is removed from the developing unit **4** and then unused developer is supplied to the empty developing unit **4**.

The used developer is collected from the developing unit **4** as follows: Referring to FIGS. **1** and **4**, first, the developing unit **4** is detached from the copier **100**, and then the used developer is collected through the toner supply port **95**.

Alternatively, a developer outlet and a shutter to open/close this developer outlet can be provided on a bottom portion of the developing unit **4**, and the copier **100** can be configured to offer a developer discharge mode that is selectable via the operating unit **194** (shown in FIG. **16**). When this developer discharge mode is executed, for example, the shutter opens and each screw in the developing unit **4** starts rotating, discharging the used developer from the developing unit **4** through the developer outlet.

It is to be noted that, if the developing unit **4** is filled with the developer before shipment, and the copier **100** is shaken or tilts during transport, the developer might spill out from the opening of the developing unit **4**. Further, the developer might deteriorate by being exposed to air. Therefore, the developer is supplied to the developing unit **4** at the user's site.

A developer supply operation is described below with reference to FIGS. **9** and **12** through **15**.

Referring to FIG. **9**, a front door is provided on the front side of the copier **100** so as to detach the toner supply unit **500** from the copier **100**. First, the front door is opened and power to the copier **100** is turned off, after which the toner supply unit **500** is detached therefrom.

After the toner supply unit **500** is thus removed from the copier **100**, the toner supply port **95** of each developing unit **4** appears as shown in FIG. **13**. Subsequently, as shown in FIG. **14**, the maintenance person attaches the lever **147** to the tip portion of the shaft **144***a* of the second disengagement cam **144**, and then rotates the lever **147** counterclockwise in FIG. **14** so as to disengage the intermediate transfer belt **110** from all the photoreceptors **1**Y, **1**M, **1**C, and **1**K as shown in FIG. **12**.

Then, referring to FIG. **15**, the maintenance person attaches a toner bottle **120** serving as a developer container containing unused developer to the developing unit **4** so that a developer supply port of the toner bottle **120** engages the toner supply port **95**.

In an initialization operation that is performed when the copier **100** arrives at the user's site, the toner bottles **120** for yellow, magenta, cyan, and black are respectively set on the toner supply ports **95** of the corresponding colors. In developer replacement work, a corresponding toner bottle **120** is set on the toner supply ports **95** of the developing unit **4** from which the used developer is removed.

Then, the maintenance person removes a heat seal covering the developer supply port of the toner bottle **120**, closes the front door of the copier **100**, and then turns on the power. Further, the maintenance person calls up a hidden menu via a display of the operating unit (operation panel) **194** (shown in FIG. **16**), selects the color of the toner bottle **120** set on the developing unit **4**, and then executes a developer supply mode. It is to be noted that the developer supply mode is performed for each color in the initialization operation.

When the developer supply mode is executed, each screw in the developing unit **4** starts rotating so as to transport and uniformly distribute the unused developer supplied from the toner bottle **120** in the developing unit **4**.

It is to be noted that, while the developer supply mode is executed, the photoreceptor **1** can be rotated as well so as not to be damaged by newly supplied carrier adhered to the developing roller **5** (shown in FIG. **2**). Further, because the cleaning blade (drum cleaner) might turn outward or inward if the photoreceptor **1** is kept rotating while the toner is not supplied thereto, a belt-shaped image can be formed on the photoreceptor **1** after a sufficient or given amount of the developer is supplied thereto so that the cleaning blade is supplied with the toner.

When all yellow, magenta, cyan, and black are selected in the developer supply mode, the yellow, magenta, cyan, and black developers are supplied, sequentially or simultaneously, to the respective developing units **4** in the present embodiment.

After all unused developer in the toner bottle **120** is supplied to the developing unit **4** and the developer supply mode is completed, the maintenance person turns the power off, opens the front door, and then attaches the toner supply unit **500** to the copier **100**. Then the maintenance person closes the front door, turns on the power again, and then performs an initial setting operation to achieve a proper or desired image density. The initial setting operation includes calibrating the sensitivity of the toner concentration sensor **191** (shown in FIG. **2**), setting image forming condition, etc.

The sensitivity of the toner concentration sensor **191** can be calibrated as follows: The unused developer contained in the toner bottle **120** has a predetermined or given toner concentration, and thus toner concentration in the developing unit **4** equals that value after the unused developer is supplied thereto. For example, the unused developer has a toner concentration of 7% in the present embodiment. Therefore, the sensitivity of the toner concentration sensor **191** is adjusted so that an output value thereof indicates a toner concentration of 7%.

Further, the image forming conditions are set as follows: Referring to FIG. **2**, a predetermined or given test pattern is formed on the photoreceptor **1**, and then the toner adhesion detector **190** detects the amount of the toner adhered to the test pattern. Based on results of the detection, development bias, charge bias, intensity of the exposure light, etc., are adjusted.

After the initial setting operation is completed, the maintenance person opens the front door of the copier **100**, rotates the lever **147** shown in FIG. **14** so as to set the intermediate transfer belt **110** to the partial disengagement mode shown in FIG. **11** from the full disengagement mode shown in FIG. **12**, and then closes the front door.

FIG. **16** is a block diagram illustrating main elements of control circuitry of the copier **100**.

Referring to FIG. **16**, the controller **198** includes a CPU (Central Processing Unit) serving as a computing unit, a nonvolatile RAM (Random Access Memory) serving as a data storage unit, a ROM (Read Only Memory) serving as another data storage unit, etc. The controller **198** is connected to the toner adhesion detector **190**, the toner concentration sensor **191**, a photoreceptor motor **192** that drives the photoreceptor **1**, a development motor **193** that drives the developing unit **4**, the operating unit **194**, a position detector **195** that detects position of the intermediate transfer belt **110**, a photoreceptor motor torque detector **196**, a development motor torque detector **197**, and a belt driving motor torque detector **199**.

It is to be noted that, although the controller **198** performs overall control of the copier **100** and various devices and sensors are connected thereto, only the devices and the sensors that concern features of the copier **100** are shown in FIG. **16**.

The controller **198** implements functions of the respective parts according to control programs stored in the RAM and the ROM. More specifically, when execution of the developer supply mode is instructed via the operating unit **194**, the controller **198** drives the photoreceptor motor **192** and the development motor **193**, thus serving as a developer supply controller.

As noted previously, in the developer supply operation described above, if unused developer is supplied to the developing unit **4** in which developer is present (redundant replenishment) due to human error, the copier **100** might be seriously contaminated or damaged.

In view of the foregoing, in a process whose steps are illustrated in the flow chart shown in FIG. **17**, at S**1** the controller **198** confirms that the developer container part of the developing unit **4** is empty, and then at S**2** executes the developer supply mode only when the developer is not present therein, that is, the developing unit is empty (YES at S**1**) in order to prevent such human error.

The present embodiment is described below in further detail with reference to FIGS. **16** and **18**.

FIG. **18** illustrates a procedure to execute the developer supply mode, in which the controller **198** checks for the presence of the developer in the developer container part of the developing unit **4** based on an output value V_t from the toner concentration sensor **191** serving as a developer detector.

First, the maintenance person sets the toner bottle **180** (shown in FIG. **15**) on the toner supply port **95** (shown in FIG. **14**) of the developing unit **4**, and then instructs the copier **100** to execute the developer supply mode via the operating unit **194**. Subsequently, referring to FIG. **18**, at S**11** the controller **198** activates the toner concentration sensor **191** that in the present embodiment is a magnetic permeability sensor, and at S**12** checks whether or not an output value V_t therefrom is lower than a predetermined or given threshold V_{ref}.

When the toner concentration in the developing unit **4** is lower, that is, a relatively large amount of the carrier is present in an area detected by the toner concentration sensor **191**, magnetic permeability thereof is relatively high, and accordingly the output value V_t is higher. By contrast, when the toner concentration in the developing unit **4** is higher, that is, a relatively small amount of the carrier is present in the area detected by the toner concentration sensor **191**, magnetic permeability thereof is lower, and accordingly the output value V_t is lower.

In other words, when the developing unit **4** is empty, the output value V_t as well as the magnetic permeability therein are significantly low. Therefore, when the output value V_t of the toner concentration sensor **191** is lower than the threshold V_{ref} (YES at S**12**), the developing unit **4** can be regarded as being empty. Then, at S**13** the controller **198** executes the developer supply mode, driving the collection screw **6**, the supply screw **8**, the agitation screw **11** (developer transporters), etc., in the developing container part shown in FIG. **2**.

By contrast, when the output value V_t of the toner concentration sensor **191** is higher than the threshold value V_{ref} (NO at S**12**), the controller **198** displays an error message on the operating unit **194**, etc., and terminates the procedure. Thus, redundant replenishment of the developer can be prevented. Further, because the toner concentration detector **191** serves as the developer detector to detect presence of the developer in the developer container part of the developing unit **4**, a separate developer detector is not required, saving both the number of components used in the copier **100** as well as the cost thereof.

Another illustrative embodiment is described below with reference to FIGS. **16** and **19**.

FIG. **19** illustrates another procedure to execute the developer supply mode, in which the presence of the developer in the developer container part is detected based on torque of the developer transporter or the development motor **193**.

First, the maintenance person sets the toner bottle **120** (shown in FIG. **15**) on the toner supply port **95** (shown in FIG. **14**) of the developing unit **4**, and then instructs the copier **100** to execute the developer supply mode via the operating unit **194**. Subsequently, referring to FIG. **19**, at S**21** the controller **198** activates the development motor **193** so as to drive the developing roller **5**, the collection screw **6**, the supply screw **8**, and the agitation screw **11** shown in FIG. **2**.

At S**22**, the controller **198** activates the development motor torque detector **197** so as to detect torque of the development motor **193**. The development motor torque detector **197** monitors a driving current of the development motor **193** and then converts it into torque, which is used to detect an abnormal state of the development motor **193** and the developing unit **4**.

At S**23**, the controller **198** checks whether or not the detected torque T of the development motor **193** is lower than a predetermined or given threshold T_{ref}. Because the torques of the collection screw **6**, the supply screw **8**, and the agitation screw **11** are higher, and accordingly the detected torque T is higher when the developer is present in the developing unit **4**, the presence of the developer can be detected based on the torque of the development motor **193**.

When the detected torque T is higher than the threshold T_{ref} (NO at S**23**), that is, the developer is present in the developer container part of the developing unit **4**, the controller **198** displays an error message on the operating unit **194**, etc., stops the development motor **193** at S**25**, and terminates the procedure.

By contrast, when the detected torque T is lower than the threshold T_{ref} (YES at S**23**), that is, the developer is not present in the developer container part, at S**24** the controller **198** executes the developer supply mode and then stops the development motor **193** at S**25**.

It is to be noted that, although the development motor **193** is driven so as to detect the torque, the developer does not spill over from the developing unit **4** even if the developer is already present therein because driving time of the development motor is very short, supplying a very small amount of the developer, if any.

As described above, redundant replenishment of the developer can be prevented as well in the present embodiment because, when the developer is present in the developing unit **4**, the developer is not supplied from the toner bottle **120** thereto. Further, because the development motor **193** and the development motor torque detector **197** serve as the developer detector, a separate developer detector is not required, saving both the number of components used in the copier **100** as well as the cost thereof.

Another illustrative embodiment is described below with reference to FIGS. **16** and **20**.

FIG. **20** illustrates another procedure to execute the developer supply mode, in which a predetermined or given image is formed on the photoreceptor **1** as a developer detection pattern, the amount of the toner adhered to the developer detection pattern is detected, and then the presence of the developer in the developer container part is detected based on results of the detection.

First, the maintenance person sets the toner bottle **120** (shown in FIG. **15**) on the toner supply port **95** (shown in FIG. **14**) of the developing unit **4**, and then instructs the copier **100** to execute the developer supply mode via the operating unit **194**. Subsequently, referring to FIG. **20**, at S**31** the controller **198** activates the photoreceptor motor **192** and the development motor **193**, and simultaneously, causes the charger and the development bias applicator to generate the charge bias and the development bias, respectively, at S**32**. Then, the developer detection pattern is formed on the photoreceptor **1** at S**33**, and then the controller **198** activates the toner adhesion detector **190** to detect the developer detection pattern at S**34**. At S**35**, the controller **198** checks whether or not an output value Vsp of the toner adhesion detector **190** is higher than a predetermined or given threshold Vref at S**35**.

The toner adhesion detector **190** in the present embodiment is a reflection optical sensor, and the output value V_{sp} is lower when the amount of the toner adhered to the photoreceptor **1** is larger and higher when the amount of the toner adhered to the photoreceptor **1** is smaller. When the developer is not present in the developing unit **4**, the toner does not adhere to the developer detection pattern on the photoreceptor **1**, and accordingly the output value V_{sp} is higher than the threshold V_{ref}.

Therefore, when the output value V_{sp} is higher than the threshold V_{ref} (YES at S**35**), the controller **198** executes the developer supply mode at S**36**. By contrast, when the output value V_{sp} is lower than the threshold V_{ref} (NO at S**35**), that is, there is some toner adhered to the developer detection pattern, the controller **198** determines that the developer is present in the developing unit **4**. Consequently, the controller **198** displays an error message on the operating unit **194**, etc.

Then, the controller **198** turns off the charger and the development bias applicator at S**37**, and further turns off the photoreceptor motor **192** and the development motor **193** at S**38**.

It is to be noted that, although the development motor **193** is driven so as to form the developer detection pattern, the developer does not spill over from the developing unit **4** even if the developer is already present therein because driving time of the development motor is very short, supplying a very small amount of the developer, if any.

As described above, redundant replenishment of the developer can be prevented as well in the present embodiment because, when the developer is present in the developing unit **4**, the developer is not supplied from the toner bottle **120** thereto. Further, because the toner adhesion detector **190** serves as the developer detector, a separate developer detector is not required, saving both the number of components used in the copier **100** as well as the cost.

A procedure to execute the developer supply mode according to another illustrative embodiment is described below with reference to FIGS. **21** though **23**.

If the maintenance person forgets to disengage the intermediate transfer belt **110** from the photoreceptors **1** before executing the developer supply mode, the intermediate transfer belt **110** might rub against the photoreceptors **1**, damaging the surfaces thereof. Therefore, in the present embodiment, the controller **198** checks whether or not the intermediate transfer belt **110** is disengaged therefrom before executing the developer supply mode as shown in FIG. **21**.

Referring to FIG. **21**, at S**41** the controller **198** activates the toner concentration sensor **191**, and checks whether or not the output value V_t is lower than the threshold V_{ref} so as to confirm that the developer is not present in the developing unit **4** at S**42**. When the output value V_t is lower than the threshold V_{ref} (YES at S**42**), the controller **198** checks whether or not the intermediate transfer belt **110** is disengaged from the photoreceptors **1** at S**43**. After confirming that the intermediate transfer belt **110** is disengaged from the photoreceptors **1** (YES at S**43**), the controller **198** executes the developer supply mode at S**44**.

It is to be noted that, alternatively, presence of the developer may be determined based on the amount of the toner adhered to the photoreceptor **1** or the torque of one of the development motor **193** and the photoreceptor motor **192** as described above.

Further, the procedure described above is performed when black or all colors is selected in the developer supply mode because the partial disengagement mode shown in FIG. **11** is set as the default mode in the present embodiment.

This procedure is described in further detail below.

Referring to FIG. **22**A, a disengagement unit **140**A according to the present embodiment includes a filler **182** protruding from a bottom surface of the second arm **143** and a position detector **195** as a disengagement detector to detect disengagement between an intermediate transfer belt **110** and photoreceptors **1**. Other than that, the disengagement unit **140**A has a configuration similar to that of the disengagement unit **140** shown in FIG. **10**, and thus a description thereof is omitted.

The position detector **195** in the present embodiment is a transmissive optical sensor including a light emitting element and a light receiving element arrayed to face each other at a predetermined or given distance apart, and detects a position of the intermediate transfer belt **110**.

In the partial disengagement mode shown in FIG. **22**A, in which the second disengagement cam **144** is at the engagement position to engage the intermediate transfer belt **110** with the photoreceptor **1**K, the light receiving element receives light emitted from the light emitting element, and the position detector **195** outputs a predetermined or given value.

By contrast, when the intermediate transfer belt **110** is disengaged from the photoreceptor **1**K by rotating the second disengagement cam **144** to the disengagement position using the lever **147** shown in FIG. **14**, the filler **182** moves to between the light emitting element and the light receiving element. In this state, the filler **182** interrupts the light emitted from the light emitting element, and the output value from the light receiving element decreases.

Thus, the position detector **195** can detect that the intermediate transfer belt **110** is disengaged from the photoreceptor **1**K based on the rotational position of the second disengagement cam **144**.

The procedure using the filler **182** and the position detector **195** is described below with reference FIGS. **22**A, **22**B, and **23**.

When the developer supply mode is executed regarding the developing unit **4**K for black, the controller **198** performs steps S**51** and S**52** that are similar to the steps S**41** and S**42** shown in FIG. **21**, and thus descriptions thereof are omitted. After thus confirming that the developer is not present in the developing unit **4**K, the controller **198** checks whether or not the position detector **195** detects the filler **182** at S**53**. When the position detector **195** detects the filler **182** (YES at S**53**), that is, the intermediate transfer belt **110** is disengaged from the photoreceptor 1K, the controller **198** executes the developer supply mode at S**54**.

By contrast, when the position detector **195** does not detect the filler **182** (NO at S**53**), the intermediate transfer belt **110** is in the partial disengagement mode and contacts the photoreceptor **1**K, that is, the maintenance person has forgotten to rotate the lever **147** shown in FIG. **14**. Therefore, the controller **198** causes the operating unit (operation display) **194** to display an error message, and terminates the procedure.

As described above, in the present embodiment, the developer supply mode is not executed while the intermediate transfer belt **110** engages the photoreceptors **1**, preventing damage to the photoreceptors **1** and the intermediate transfer belt **110** caused by rubbing against each other.

Another illustrative embodiment in which the disengagement between the intermediate transfer belt **110** and the photoreceptor **1** is confirmed based on the rotational position of the second disengagement cam **144** is described below with reference to FIGS. **24**A, **24**B, and **25**.

As shown in FIG. **24**A, a disengagement unit **140**B according to the present embodiment includes a filler **181** fixed to the shaft **144***a* and a position detector **195**A. The position detector **195**A has a configuration similar to that of the position detector **195** shown in FIGS. **22**A and **22**B. The filler **181** and the position detector **195**A serve as a disengagement detector. Other than that, the disengagement unit **140**B has a configuration similar to that of the disengagement unit **140** shown in FIG. **10**, and thus a description thereof is omitted.

When the intermediate transfer belt **110** contacts the photoreceptor **1**K, a part of the filler **181** is located between a light emitting element and a light receiving element of the position detector **195**A, interrupting the light emitted from the light emitting element. Therefore, the position detector **195**A does not output a predetermined or given output value.

By contrast, when the second disengagement cam **144** is rotated by 90 degrees or about 90 degrees to the disengagement position shown in FIG. **24**B, and accordingly the intermediate transfer belt **110** is disengaged from the photoreceptor **1**K, the light receiving element of the position detector **195**A receives the light emitted from the light emitting element. In this state, the position detector **195**A outputs a predetermined or given output value. Thus, based on the output value of the position detector **195**A, the rotational position of the second disengagement cam **144** can be detected, and accordingly disengagement between the intermediate transfer belt **110** and the photoreceptor **1**K can be detected.

The procedure using the filler **181** and the position detector **195**A is described below with reference FIGS. **24**A, **24**B, and **25**.

When the developer supply mode is executed regarding the developing unit **4**K for black, the controller **198** performs steps S**61** and S**62** that are similar to the steps S**41** and S**42** shown in FIG. **21**, and thus descriptions thereof are omitted. After thus confirming that the developer is not present in the developing unit **4**K (YES at S**62**), the controller **198** checks whether or not the second disengagement cam **144** is at the disengagement position shown in FIG. **24**B at S**63**.

More specifically, when the position detector **195**A outputs the predetermined output value, it is known that the second disengagement cam **144** is at the disengagement position as described above, and thus the controller **198** can confirm that the intermediate transfer belt **110** is disengaged from the photoreceptor **1**K. When the second disengagement cam **144** is at the disengagement position (YES at S**63**), the controller **198** executes the developer supply mode at S**64**.

By contrast, when the second disengagement cam **144** is not at the disengagement position (NO at S**63**), that is, the intermediate transfer belt **110** is in the partial disengagement mode and contacts the photoreceptor **1**K, the controller **198** causes the operating unit (operation display) **194** to display an error message, and terminates the procedure.

As described above, the developer supply mode is not executed while the intermediate transfer belt **110** engages the photoreceptors **1**, preventing damage to the photoreceptors **1** and the intermediate transfer belt **110** caused by rubbing against each other as well in the present embodiment.

Another illustrative embodiment is described below with reference to FIG. **26**.

FIG. **26** is a flow chart illustrating a procedure in which disengagement of the intermediate transfer belt **110** from the photoreceptors **1** is detected based on an output value from the photoreceptor motor torque detector **196** that is used to detect an abnormal state of the image forming apparatus **100** shown in FIG. **1** by detecting that the load of the photoreceptor motor **192** is abnormally high.

That is, the photoreceptor motor torque detector **196** serves as a disengagement detector to detect disengagement of the intermediate transfer belt **110** from the photoreceptors **1**. The photoreceptor motor torque detector **196** monitors and converts a driving current of the photoreceptor motor **192** into torque.

When the developer supply mode is executed for the developing unit **4**K for black, the controller **198** performs steps S**71** and S**72** that are similar to the steps S**41** and S**42** shown in FIG. **21**, and thus descriptions thereof are omitted. After confirming that the developer is not present in the developing unit **4**K (YES at S**72**), the controller **198** activates the photoreceptor motor **192** at S**73** and further activates the photoreceptor motor torque detector **196** at S**74** so as to detect torque of the photoreceptor motor **192**.

Then, at S**75** the controller **198** checks whether or not a detected torque T of the development motor **193** is lower than a predetermined or given threshold T_{ref}. When the intermediate transfer belt **110** contacts the photoreceptor **1**K, the torques of the photoreceptor **1**K is higher, and accordingly the detected torque T is higher than the threshold T_{ref}. Because it is known that the detected torque T is higher than the threshold T_{ref} (NO at S**75**) when the intermediate transfer belt **110** contacts the photoreceptor **1**K, the controller **198** displays an error message on the operating unit **194**, etc., and does not execute the developer supply mode.

By contrast, when the detected torque T is lower than the threshold T_{ref} (YES at S**75**), that is, the intermediate transfer belt **110** is disengaged from the photoreceptor **1**K, at S**76** the controller **198** executes the developer supply mode and then stops the photoreceptor motor **192** at S**77**.

Alternatively, disengagement of the intermediate transfer belt **110** from the photoreceptor **1** can be determined based on driving torque of the intermediate transfer belt **110** using the belt driving motor torque detector **199** shown in FIG. **16**. Alternatively, disengagement between the intermediate transfer belt **110** and the photoreceptor **1** may be detected based on driving torque of both the photoreceptor **1** and the intermediate transfer belt **110**.

As described above, the developer supply mode is not executed while the intermediate transfer belt **110** engages the photoreceptors **1** as well in the procedure described above, preventing damage to the photoreceptors **1** and the intermediate transfer belt **110** caused by rubbing against each other. Further, because the photoreceptor motor torque detector **196** serves as the disengagement detector, a separate developer detector is not required, saving both the number of components used in the copier **100** as well as the cost.

A procedure to execute the toner supply mode according to another illustrative embodiment is described below with reference to FIGS. **27** and **28**.

As shown in FIG. **27**, a disengagement unit **140**C according to the present embodiment includes a second disengagement motor **183** to rotate the second disengagement cam **144** and a driving controller **184** to control the second disengagement motor **183**, and the intermediate transfer belt **110** can be automatically disengaged from the photoreceptor **1**K. Other than that, the disengagement unit **140**A has a configuration similar to that of the disengagement unit **140** shown in FIG. **10**, and thus a description thereof is omitted.

When the developer supply mode is executed regarding the developing unit **4**K for black, the controller **198** performs steps S**81** and S**82** that are similar to the steps S**41** and S**42** shown in FIG. **21**, and thus descriptions thereof are omitted. After confirming that the developer is not present in the developing unit **4**K (YES at S**82**), the controller **198** activates the second disengagement motor **183** at S**83** so as to disengage the intermediate transfer belt **110** from the photoreceptor **1**K. Then, at S**84** the controller **198** executes the developer supply mode.

Thus, the intermediate transfer belt **110** can be automatically disengaged from the photoreceptors **1** before executing the developer supply mode in the procedure described above, preventing damage to the photoreceptors **1** and the intermediate transfer belt **110** caused by rubbing against each other.

As described above, the image forming apparatus **100** according to the illustrative embodiments of the present invention includes the photoreceptors **1** serving as the latent image carriers, the developing units **4** to respectively develop the latent images formed on the photoreceptors **1** with the developer, the developer detector to detect whether or not the developer is present in the developer container part of the developing unit **4**, and the controller **198** that supplies the developer to the developer container part from the toner bottle **120** set on the image forming apparatus **100** when the developer detector detects that the developer is not present therein.

In the configuration described above, because the developer is not supplied to the developer container part in which the developer is present, redundant replenishment of the developer due to human error can be prevented.

Further, the toner concentration sensor **191** shown in FIG. **2** can be used as the developer detector, and presence of the developer in the developer container part can be detected based on the output value thereof as shown in FIG. **18**.

Alternatively, as shown in FIG. **19**, the developer detector can be configured to detect presence of the developer in the developer container part based on the torque of the supply screw **8**, agitation screw **11**, and collection screw **6** serving as the developer transporters shown in FIG. **2**.

Alternatively, a predetermined or given image can be formed on the photoreceptor **1** as the detection pattern. Presence of the developer can be detected by detecting the amount of the toner adhered to the image with the toner adhesion detector **190** shown in FIG. **2**.

The image forming apparatus **100** further includes the disengagement unit **140** to engage/disengage the intermediate transfer belt **110** with/from the photoreceptors **1**, the disengagement detector to detect whether or not the intermediate transfer belt **110** is disengaged therefrom. The controller **198** can be configured to supply the developer to the developer container part from the toner bottle **120** only when the developer detector detects that the developer is not present therein. With this configuration, the developer supply operation is not performed unless the intermediate transfer belt **110** is disengaged from the photoreceptors **1**, preventing damage to the photoreceptors **1** and the intermediate transfer belt **110** caused by rubbing against each other.

The disengagement detector can be configured to detect disengagement between the intermediate transfer belt **110** and the photoreceptor **1** based on driving torque of one of the photoreceptor **1** and the intermediate transfer belt **110**.

Alternatively, the disengagement detector can be configured to detect disengagement between the intermediate transfer belt **110** and the photoreceptor **1** based on a detection result generated by the position detector that detects position of the intermediate transfer belt **110**.

Alternatively, position of the intermediate transfer belt **110** can be detected based on a rotational position of the disengagement cam.

Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the disclosure of this patent specification may be practiced otherwise than as specifically described herein.

What is claimed is:

1. An image forming apparatus, comprising:

a latent image carrier configured to carry a latent image thereon;

a disengagement detector configured to detect whether or not an intermediate transfer member is disengaged from the latent image carrier;

a developing unit disposed facing the latent image carrier to develop the latent image with developer;

a developer container configured to contain the developer and to be attached to the image forming apparatus;

a developer detector configured to detect presence of the developer in the developing unit; and

a developer supply controller configured to prohibit supply of the developer from the developer container to the developing unit when the developer detector detects that the developer is present in the developing unit,

wherein the developer supply controller supplies the developer from the developer container to the developing unit when the disengagement detector detects that the intermediate transfer member is disengaged from the latent image carrier.

2. The image forming apparatus according to claim **1**, wherein the developer detector is a toner concentration sensor located in the developing unit and detects the presence of the developer based on a result of toner concentration detection.

3. The image forming apparatus according to claim **1**, wherein the developing unit further comprises a developer transporter that transports the developer inside the developing unit, and

the developer detector detects presence of the developer in the developing unit based on torque of the developer transporter.

4. The image forming apparatus according to claim **1**, wherein the developer detector is a toner adhesion detector disposed facing the latent image carrier to detect an amount of the toner adhered to the latent image carrier,

a predetermined image is formed on the latent image carrier when supplying the developer to the developing unit from the developer container is instructed,

the toner adhesion detector detects the amount of the toner adhered to the predetermined image, and

the presence of the developer in the developing unit is detected based on a result of the toner adhesion detection.

5. The image forming apparatus according to claim 1, further comprising:

a transferor configured to transfer the image formed on the latent image carrier onto the intermediate transfer member; and

a disengagement unit configured to engage the intermediate transfer member with the latent image carrier and disengage the intermediate transfer member therefrom.

6. The image forming apparatus according to claim 5, wherein the disengagement detector detects whether or not the intermediate transfer member is disengaged from the latent image carrier based on driving torque of at least one of the latent image carrier and the intermediate transfer member.

7. The image forming apparatus according to claim 5, wherein the disengagement detector is a position detector that detects a position of the intermediate transfer member, and

the disengagement detector is configured to detect whether or not the intermediate transfer member is disengaged from the latent image carrier based on the position of the intermediate transfer member.

8. The image forming apparatus according to claim 7, wherein the disengagement unit includes a disengagement cam to disengage the intermediate transfer member from the latent image carrier, and

the disengagement detector detects the position of the intermediate transfer member based on a rotational position of the disengagement cam.

9. A developer supply method used in an image forming apparatus including a latent image carrier on which a latent image is formed, a developing unit configured to develop the latent image, and a developer container to be set on the image forming apparatus, the developer supply method comprising:

detecting whether or not an intermediate transfer member is disengaged from the latent image carrier;

determining whether or not developer is present in the developing unit;

prohibiting supply of the developer to the developing unit from the developer container when the developer is determined to be present in the developing unit; and

prohibiting supply of the developer to the developing unit from the developer container when the intermediate transfer member is not disengaged from the latent image carrier.

10. The developer supply method according to claim 9, further comprising detecting a toner concentration in the developing unit,

wherein whether or not the developer is present in the developing unit is determined based on a result of the toner concentration detection.

11. The developer supply method according to claim 9, further comprising detecting a torque of a developer transporter that transports the developer in the developing unit,

wherein whether or not the developer is present in the developing unit is determined based on the torque of the developer transporter.

12. The developer supply method according to claim 9, further comprising:

forming a predetermined image on the latent image carrier; and

detecting an amount of the toner adhered to the predetermined image,

wherein whether or not the developer is present in the developing unit is determined based on a result of the toner adhesion detection.

13. The developer supply method according to claim 9, further comprising:

disengaging the intermediate transfer member from the latent image carrier.

14. The developer supply method according to claim 13, wherein whether or not the intermediate transfer member is disengaged from the latent image carrier is determined based on driving torque of at least one of the latent image carrier and the intermediate transfer member.

15. The developer supply method according to claim 13, further comprising detecting a position of the intermediate transfer member,

wherein whether or not the intermediate transfer member is disengaged from the latent image carrier is detected based on the position of the intermediate transfer member.

16. The developer supply method according to claim 15, wherein the intermediate transfer member is disengaged from the latent image carrier using a disengagement cam, and

whether or not the intermediate transfer member is disengaged from the latent image carrier is detected based on a rotational position of the disengagement cam.

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